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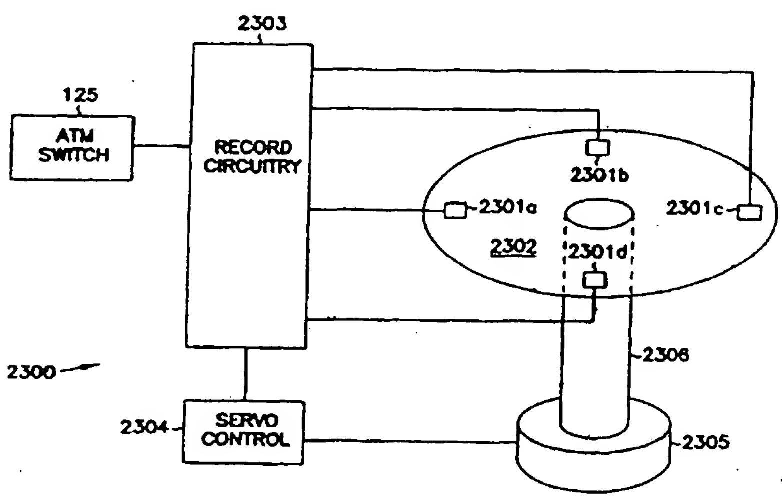

(57) Abstract

A high speed recording apparatus for Digital Versatile Disk (DVD) media is described. Four or more optical write heads disposed at equidistance locations around the surface of the recordable DVD media allow for simultaneous recording of separate segments of a contiguous data stream. The data stream may be prerecorded video stored in a digital MPEG-2 format. The DVD writing apparatus spins the DVD media using constant linear velocity (CLV) at six times or more the normal playback speed of the DVD media. The high speed recording apparatus can be used with a system for capturing, storing and retrieving prerecorded videos. A central distribution site is connected via optical fiber networks to a plurality of remote distribution locations. The remote site may be a video retail store in which a selected prerecorded video title may be manufactured on DVD media in a matter of minutes for rental or sale.

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HIGH SPEED VIDEO DIGITAL VERSATILE DISK DISTRIBUTION AND MANUFACTURING SYSTEM

FIELD OF THE INVENTION

The present patent application relates to video distribution, decompression, and rapid manufacturing and in particular to systems and methods of remote to local video distribution and local video reproduction.

BACKGROUND OF THE INVENTION

The manufacturing and distribution of prerecorded video programs and prerecorded video movies for viewing in the home is one of the largest industries in the world. The rental and sale of prerecorded videotape is a constantly growing industry amounting to over $15 billion dollars in software sales in the United States in 1995. The most popular medium for distributing prerecorded video to the home is by standard VHS videotape although other formats and mediums are available. One of the reasons for the robust market for prerecorded video on videotape is the established base of videocassette recorders (VCR) in peoples homes. This helps fuel an industry of local videotape rental and sale outlets around the country and worldwide.

The VHS videotape format is the most popular videotape format in the world and the longevity of this standard is assured due to the sheer numbers of VHS videocassette players installed worldwide. However, there are other mediums for distributing prerecorded video such as laser disk and 8mm tape. Digital Versatile Disk (DVD) technology is replacing some of the currently used mediums since a higher quality of video and audio is available through digital encoding on such a disk.

For the consumer, the experience of renting or buying a prerecorded video is often frustrating due to the unavailability of the desired titles. Prerecorded video rental and sales statistics show that close to 50% of all consumers visiting a video outlet store do not find the title that they desire and either end up renting or buying an alternate title or not purchasing anything at

all. This is due to the limited space for stocking many prerecorded video titles within the physical confines of the store. With limited inventory, video stores can only supply the most popular titles or a small number of select titles. Increasing the inventory of prerecorded video titles is in direct proportion to the shelf capacity of any one video store.

Direct video distribution to the home is also limited by the availability of select and limited titles at predefined times. Pay-per-view services typically play a limited fare of titles at predefined times offering the consumer a very short list of options for prerecorded video viewing in the home. Video on-demand to the home is limited by the cable television head end facilities in its capacity to store a limited number of titles locally.

All of the aforementioned mechanisms for distributing prerecorded video to the consumer suffer from inventory limitations. An untapped demand in prerecorded video distribution results if the inventory to the consumer can be made large enough and efficient enough to produce prerecorded video on-demand in whatever format the consumer desires. There is a need in the art, therefore, for the ability to deliver prerecorded video on-demand with a virtually unlimited library of prerecorded video on any number of mediums such as DVD technology.

Some systems have addressed the need for distribution of digital information for local manufacturing, sale and distribution. For example, U.S. Patent Number 5,418,713 to Allen described a system for on-demand data delivery and reproduction of program material at a remote site. This system describes a central site which stores digitized information such as digital video game information which can be downloaded to a manufacturing site for storage onto, for example, a blank video game cartridge. The manufactured game cartridge can be ordered on-demand from a large variety of titles and delivered to the consumer within a matter of minutes. The shortcomings of the system described in U.S. Patent Number 5,418,713 is the inability to download and manufacture or distribute large volumes of digital information such as would be

required for the downloading, distribution or manufacturing of full motion, full length prerecorded video.

Another method of delivering information is U.S. Patent Number 4,528,643 to Freeny Jr. This system provides information to a remote manufacturing machine located on a point of sale location. This system is mainly directed to reproducing pre-recorded music titles on eight-track tapes. The system also suffers from the inability to distribute large volume of digital data necessary for full motion full length movies on videotape and the like and lacks the ability to produce a videotape at high speeds.

A limited number of systems are also known in the art for writing videotaped information at speeds greater than the normal playback speeds. For example, U.S. Patent Number 4,872,070 to Cooper et al. describes a system and method for high speed videotape reproduction. The source of the video information for reproduction is from a laser disc player which is specially equipped with two optical read heads. The optical disc player also rotates the disc at twice the standard speed allowing information to be read from the optical disc at four times its standard playback rate. In a similar fashion, the helical scan videotape recorder unit has two write head pairs for writing the video information on the videotape and parallel while the tape is moved at twice its normal speed thus producing a 4X write capability. This system lacks the ability to write videotapes at higher than four times their normal viewing speed and requires that the video information come from a video disc player. Although two parallel video signal paths are described, the system lacks the ability to decompress video images from a compressed video file format.

Another system known in the art for writing videotape at a speed faster than the normal viewing speed is found in U.S. Patent Number 5,065,258 to Warren et al. This system is an analog to analog system in which an analog videotape is played at a higher than normal speed and the signals therefrom are recorded by a second video recorder at the same higher than normal viewing speed. This system lacks the ability to write videotapes at more than twice the

normal viewing speed and lacks the ability to process parallel streams of video data from a compressed file format.

Another type of video duplication device is shown in U.S. Patent Number 5,260,800 to Sturm et al. This system duplicates video cassette tapes at twice the normal viewing speed. The source video information comes from modified video disc players which operate at twice the normal NTSC video format speed. The video and audio information is converted to analog signals which are written at twice the normal viewing speed by a modified VHS video cassette recorder. This system lacks the ability to duplicate a videotape at anything more than twice the normal viewing speed and operates only in the analog domain. This system lacks the ability to write video cassette tapes using parallel data streams of compressed data from a digitally encoded file.

One type of optical disk recording is U.S. Patent No. 5,535,186 to Ishizawa. This system records digital data on optical media using Constant Linear Velocity by changing the speed of the disk such that the data recording rate stays constant. This system is limited in its speed of recording due to the use of an single recording head and speed control limitations.

There is a need in the art, therefore, for a method and system of distributing large volumes of digital information representing full length, full motion prerecorded video in a video format to remote locations for on-demand purchase or rental. This need in the art is directed both to on-demand video distribution through cable television headends or through the availability and manufacturing of prerecorded video titles on videotape or other medium at video rental retail outlets. There is also a need in the art to track the distribution of a large number of prerecorded video titles for accounting and copyright compliance. There is a further need in the art for the automated inventory tracking and billing for the distribution of a large volume of titles for prerecorded video. There is a further need in the art for manufacturing video tapes at many times the normal viewing speed from digitally compressed and stored data files. There is a further need in the art for high speed mass duplication of prerecorded video in a manufacturing setting, and in real time

distribution of digital data for real time mass duplication of prerecorded video in a manufacturing setting.

SUMMARY OF THE INVENTION

The present invention solves the above-mentioned problems in the art and other problems which will be understood by those skilled in the art upon reading and understanding the present specification. The present invention provides a high speed recording apparatus for Digital Versatile Disk (DVD) media. Four or more optical write heads disposed at equidistance locations around the surface of the recordable DVD media allow for simultaneous recording of separate segments of a contiguous data stream. The data stream may be prerecorded video stored in a digital MPEG-2 format. The DVD writing apparatus spins the DVD media using constant linear velocity (CLV) at six time or more the normal playback speed of the DVD media. The high speed recording apparatus can be used with a system for capturing, storing and retrieving prerecorded videos. A central distribution site is connect via optical fiber networks to a plurality of remote distribution locations. The remote site may be a video retail store in which a selected prerecorded video title may be manufactured on DVD media in a matter of minutes for rental or sale.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, where like numerals refer to like components throughout the several views,

Figure 1 is a diagram of a video distribution and manufacturing system;

Figure 2 is a map of the United States showing some of the currently installed OC-12 fiber optic connections which may be used for the distribution of large data files such as digitally encoded prerecorded video;

Figure 3 is a block diagram of the decompression engine;

Figure 4 is a diagram indicating the two parallel formats in which the decompression engine may operate;

Figure 5 is a block diagram showing the general architectural design of the parallel processing of the decompression engine;

Figure 6 is a more detailed description of the parallel operation of an individual parallel processing pipeline of Figure 5;

Figure 7 is a detailed top-level architectural view of the decompression engine and its associated buffers of Figure 3;

Figure 8 is an even more detailed description of the video decompression engine output section memory architecture for the video pipeline processors of Figure 3;

Figure 9 is a diagram of the high-speed video writer hardware;

Figure 10 is a more detailed diagram of the operation of the high-speed recorder of Figure 9;

Figure 11 is a detailed view of the video tape showing the video fields and audio fields recorded on the tape with the simultaneously recording heads;

Figure 12 is a diagram of the normal VHS frequency spectrum on the tape for recording the chrominance, luminance and hi-fi audio information;

Figure 13 is a diagram of the enhanced frequency spectrum used for recording the chrominance, luminance and hi-fi audio information onto the video tape at higher tape travel speeds;

Figure 14 is a diagram of the individual video data and analog information paths for the eight video heads described in Figure 11;

Figure 15 is a diagram of a plurality of high-speed video recorders combined into a single robotic cabinet;

Figure 16 is a diagram of the kiosk process and database flow;

Figure 17 is a diagram of the operation flow of the retail outlet manufacturing process;

Figure 18 is a diagram of the financial transaction flow for the purchase or rental of a movie;

Figure 19 is a diagram of the digital prerecorded video data flow at the retail manufacturing site;

Figure 20 is a more detailed diagram of the digital prerecorded video data flow and conversion;

Figure 21 is a diagram showing direct video on demand delivery;

Figure 22 shows a manufacturing environment according to an alternate embodiment of the present invention;

Figure 23 shows a block diagram for the High Speed DVD writer;

Figure 24 is a top view of the sector format of a typical DVD disk; and

Figure 25 is a side view of a multi-layer DVD recordable disk.

Detailed Description of the Preferred Embodiment

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific preferred embodiments in which the inventions may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural, logical and electrical changes may be made without departing from the scope of the present inventions. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present inventions is defined only by the appended claims.

System Overview

A video distribution and manufacturing system is shown in the block diagram of Figure 1. The top half of Figure 1 describes a host data center 10 which would be located at a central location and serving a wide area of remote manufacturing locations across a wide geographic area. The bottom half of Figure 1 describes one of a plurality of remote manufacturing centers 20 which would be located at a plurality of locations. The remote manufacturing center 10 in the preferred embodiment is connected with a plurality of remote manufacturing centers through a fiber optic network connection in the preferred embodiment. As will be described more fully below, alternate means of communicating between the host data center and the plurality of remote manufacturing centers may be through satellite communication, land-wire connection and other types of communication mediums.

The present invention in the preferred embodiment is designed to distribute and manufacture on-demand full-length prerecorded video (such as movies, TV programs, information tapes, music videos, sporting events, infomertials, educational videos, and the like) at the plurality of remote manufacturing sites for a user while he or she waits for the tape to be manufactured. The advantage of the present invention is that the remote manufacturing outlets in the form of retail video stores virtually never run out of stock for a particular prerecorded video title whether it be for a rental or sell-through. The prerecorded video is manufactured while the customer waits using high-speed video recording devices. The prerecorded video content is either stored locally at the remote manufacturing site in a compressed digital format such as MPEG-2, or the prerecorded video is downloaded from the host data center via the communications medium. The typical time for writing a two-hour VHS prerecorded video for playback at SP (standard play) speed is typically 3 minutes. Downloading the prerecorded video from the host data center may add an increment of one or two minutes to the overall manufacturing time. Those skilled in the art will readily recognize that the present system is adaptable to writing the prerecorded video information in a variety of formats such as digital video disk (DVD), 8 millimeter videotape, etc.

The remote manufacturing site may also have the capability of producing artwork for the packaging of the prerecorded video which is either being sold or rented. The artwork, like the prerecorded video data itself, is in a digitized form associated with the prerecorded video and either stored locally at the remote manufacturing site or downloaded from the host data center. The artwork may be generated along with tape labels and the like by a local artwork printer device.

Associated with the present invention is a transaction and accounting system which monitors the distribution and manufacturing of all prerecorded video at all the remote sites for proper accounting to the copyright holders and distribution agents for each transaction.

The present invention in an alternate embodiment is designed to distribute and manufacture on-demand full-length prerecorded video (such as movies, TV programs, information tapes, music videos, sporting events, infomertials, educational videos, and the like) to a plurality of mass duplication machines in a manufacturing environment. The video duplicators may be real time, or high speed duplicators.

Video Distribution Block Diagram

Figure 1 is a block diagram of the preferred embodiment of the present invention. The process begins with the studio content provider in which the prerecorded video may be provided in a film form or in an analog video format or in an already digitized version. Whatever the original format, the prerecorded video must be placed in a compressed digital format through the video capture center 103. The video capture center 103 is required to put the digitized image of the prerecorded video into a modified MPEG-2 format in the preferred embodiment of the present invention. The digital encoding process use an eight-wide parallel encoder to facilitate the high speed manufacture of the movie, as described more fully below. A portion of the video capture center 103 is a quality assurance step to make sure that the video transfer was done properly and the quality of the transfer is good.. The captured video data of the prerecorded video from the video capture center 103 is transferred to a storage system 105. In the preferred embodiment of the present invention, the data transfer from the video capture center to the storage system is done locally at the host data center using a local asynchronous transfer mode packet protocol over fiber optic links through an asynchronous transfer mode (ATM) switch 113. The prerecorded video in its digitized, parallelized and compressed format is stored at the prerecorded video servers 105 on high-speed rotating mass storage (fixed disk drives), optical storage or archived in tape storage. A typical two-hour prerecorded video is compressed into a file approximately 4 gigabytes in size.

The host data center operation is controlled by a number of computers which are interconnected in a symmetric multiprocessing configuration. One of the primary functions of the host data center is the

distribution of the digital video files containing the prerecorded video images. This is an I/O-bound application requiring high data bandwidth to transfer the prerecorded video but very little processing. Another function of the host data center is the accounting and transaction information and the prerecorded video database cataloging. The overall design of the host data center, as described more fully below, is modular and expandable so that the host data center can expand to service a larger and growing number of video retail outlets also known as the remote manufacturing centers. The symmetric multiprocessing environment is configured as a bus architecture using multiple P5 processors or the like. Multiple processors are configured to operate in parallel which allows the expendability of the system by adding additional processors and, therefore, additional processing capacity to handle more prerecorded video transactions and prerecorded video distributions.

Also included at the host data center is the transaction engine 109 which communicates with the plurality of remote manufacturing sites to monitor the number of sales and rentals of various prerecorded video distributed through the remote manufacturing outlets. The accounting and transaction engine 109 can communicate with the other components of the host data center to keep a current accounting of all transactions. In addition, the accounting and transaction engine 109 can communicate with electronic money banking system to credit and debit accounts on a daily basis, if necessary, or less often if desired.

Communication Medium

The ATM switch 113 allows the high-speed transfer of prerecorded video and other account and transaction information from the host data center to the plurality of remote manufacturing sites through fiber optic cabling networks. In the preferred embodiment of the present invention, an ATM SONET OC-12 fiber optic network would be desirable to transfer the prerecorded video files at the highest possible transfer rates. As described above, each two-hour prerecorded video typically is stored in approximately 4 gigabytes of memory. To transfer a 4 gigabyte file over an ATM SONET OC-12 network would take approximately 3 minutes.

Figure 2 is a representative drawing of the United States showing some of the currently existing OC-12 fiber optic connections around the country. This map is representative only and not an exhaustive example of all available connections. By placing a host data center 10 at, for example, Salt Lake City, Utah, the entire nation could be serviced through the fiber optic channels connecting most major cities in the United States. There is enough connectivity through Salt Lake City to allow for backup links should any of the other major links become severed thereby ensuring uninterrupted service from the host data center to the remote manufacturing sites. As shown in Figure 2, a plurality of remote manufacturing sites may be located at Phoenix, Minneapolis, Miami and New York, by way of example but not by limitation. Also, cable television headends 30 located at Los Angeles and Detroit receive prerecorded video in a compressed format from the central data center 10 for on-demand viewing by local CATV subscribers.

Overview of the Remote Manufacturing Sites

Referring once again to Figure 1, the remote manufacturing site is also described. The compressed digital representations of the prerecorded video are either stored locally in the dedicated superservers in local mass storage system 117 of the remote manufacturing site or they are downloaded from the host data center for storage on the local mass storage of the dedicated superservers 117. The dedicated server 117 includes a local storage cache of prerecorded video designed to locally hold the top 100 prerecorded videos such that 90% of all the prerecorded videos manufactured at the remote manufacturing site will come out of the local storage cache within the server 117. In this fashion the fiber optic communication network is not needed for every manufacturing task. In order to keep the cache at its optimum operating level, statistics are kept locally on the most frequently requested prerecorded videos. and new releases such that the cache is utilized at the highest rate and the communications medium is utilized only in the least amount of time.

Each remote manufacturing site keeps statistics based on local tastes of what the most frequently requested prerecorded videos are in terms of

statistical demand. The dedicated server 117 keeps information about current and future releases so that information is available to customers as to time and dates of availability. These are also kept in the statistical database to service the client.

The primary customer interface is the customer preview and order kiosks 123. These are connected to the dedicated superserver 117 to obtain customer information and order data and to allow customers to preview excerpts from prerecorded videos contained in the repertoire of the entire system. The server 117 contains preview information in the cache and should the requested preview not be available locally, the server 117 requests the downloading of the preview through the ATM connection 113 from the central site 10. In this fashion all preview information about the entire prerecorded video database of the system is available on a near-instantaneous basis to customers operating the kiosks 123. The kiosks 123 gather information regarding customer requests, preview and general customer interest in different types of products, which are described more fully below.

The retail outlet manufacturing controller and point of sale computer 124 is also connected to the dedicated server 117 with its associated cache. The customer can order a specific prerecorded video through the kiosk 123 and the retail computer 121 orders the manufacture of the prerecorded video and processes the transaction. The retail outlet controller 12 :quests that the server 117 produce the prerecorded video on, for example, a HS tape and the availability is checked against the local cache within server 117. If the prerecorded video is not locally available, the server 117 will request the downloading of the prerecorded video from the manufacturing controller 107. Whether the prerecorded video is available locally in the cache or whether the prerecorded video must be downloaded, the prerecorded video is transferred to the high speed video recorder 115 for the manufacture of the movie.

The prerecorded video is produced by a high speed recording device 115 which in the preferred embodiment of the present invention is a 40X high-speed VHS recorder which can write (record) a prerecorded video at forty-

times its normal viewing speed. This is roughly equivalent to recording a two-hour VHS tape at SP (Standard Play) speed in approximately three minutes. In this fashion, the selected videotape prerecorded video is manufactured at the site from a blank videotape or a recycled videotape. The high speed recorder simultaneously writes 8 fields of video information to the videotape using a multiple-write-head helical scan drum which rotates at 5 times the normal rotation speed. By moving the tape at 40 times its normal speed, the resulting write rate is 40 times normal. In addition, the helical scan write head also includes multiple hi-fi audio record heads operating to record 8 frames of hi-fi audio information on top of the video information on the tape. Finally, linear stereo record heads and control track record heads operate at 40 times the normal frequency to record the linear stereo and control information on the VHS videotape.

In the preferred embodiment of the present invention the high-speed VHS recording unit 115 is placed within, or connected to, at least one robotic cabinet 130 for robotic storage and retrieval of VHS cassette tapes. The tapes are retrieved from this storage cabinet 130 and loaded under robotic control into the high-speed VHS recorder within unit 115. Also included in the high-speed VHS recorder unit is the ability to recode and refurbish tapes which are returned after rental by the consumer. This return, recode and refurbish (3R) capability is used to ensure the high quality of the videotape prerecorded video product by tracking the use of the videotape by means of specially encoded information placed on the tape. In the preferred embodiment of the present invention such information encoded on the videotape would be, by way of example and not by limitation, the number of times the tape has been recorded, the number of rentals on this tape, the last user to check out this videotape and other processing and tracking information. This information is written in the linear audio or control track either as a header or trailer of the videotape, before or after the movie. This information could also be written in the vertical blanking interval though the video record heads. A more detailed description of this information is described below.

Detailed Description of the Host Data Center

The Host Data Center 10 is, in the preferred embodiment, located in a central location to service a large geographic region. To service the United States, Salt Lake City, Utah has been chosen due to its excellent connectivity to the nation's fiber optic networks and other factors. Those skilled in the art will readily recognize that the components of the host data center 10 do not necessarily need to be located in the same geographic location. The video capture facility maybe located at the Host Data Center 10 site or it may be located at any other convenient location. For example, the video capture facility could be located closer to major prerecorded video studios in Hollywood, California.

Video Capture Facility

The video capture facility 103 receives the movies or prerecorded videos from the studio content provider 101. This maybe any number of content providers such as Universal Studios, MGM, Time Warner, etc. The studio content maybe provided in any number of formats including 16mm film, or any number of electronic video formats in the form of video movies, music videos, instructional videos, etc. The video capture facility receives the content in its source format and transfers it to the specific compressed and encoded MPEG-2 format used by the present invention.

Also captured by the video capture center are materials associated with each prerecorded video such as prerecorded video previews, prerecorded video labels, prerecorded video sell-through artwork in digital, analog and photographic forms. All this additional material is also transferred to a digital format and stored in files associated with the movie. The artwork can be transferred from the central site 10 to the remote manufacturing site 20 for use in reproducing the artwork for the jackets or covers on the videotape shells and cases. The preview information is used by the customer preview and order kiosks 123. The digitized versions of the prerecorded videos, and the associated artwork and previews, are all identified and tracked through a relational database in the manufacturing controller 107 as described more fully below.

The digital video and audio information for a prerecorded video is encoded and compressed in an MPEG-2 format which is later parallel decompressed using a compression engine described below. In operation, the chrominance, luminance and audio information of the digitized video signal representing the full motion prerecorded video is placed in an MPEG-2, or similar, format in which each frame of video is encoded. In the preferred embodiment, eight frames of video information are later decoded and processed in parallel from the MPEG-2 format corresponding to one rotation of the helical scan write head of the high speed video recorder. Then, the next eight frames are decompressed such that the data description of the overall prerecorded video represents eight frame segments or groups of pictures (GOP). Those skilled in the art will readily recognize that the parallel process of decompression of the MPEG-2 format decompress segments of a single frame of the picture rather than decompressing whole frames in parallel. This latter approach is called parallel over space compression in which each video frame would be segmented into eight segments and each of the eight segments would be decompressed in parallel from the MPEG-2 format.

In the preferred embodiment, the present invention uses the Closed GOP (Group Of Pictures) structure of MPEG-2. MPEG-2 works on frames of pictures where each frame is a complete picture. MPEG-2 uses a reference frame for the first complete picture and uses update frames to paint only those pixels or portions of the reference frame that have changed. In an open GOP format, MPEG-2 paints a reference frame followed by a variable number of update frames. In a Closed GOP format, a reference frame is followed by a fixed number of updates to paint the subsequent frames.

The present invention uses Closed GOP format using a reference frame and a fixed number of updates frames. Closed GOP is part of the MPEG-2 standard such that the decoding in the decompression engine of the present invention is done using standard MPEG-2 decoder chips. To encode the MPEG-2 file for the prerecorded video, special encoding is required to specifically encode the MPEG-2 files in a Closed GOP format.

Once encoded, the entire full motion video with audio is stored in a MPEG-2 Closed GOP data file occupying approximately four gigabytes of space. This file is then stored and cataloged, along with any associated files containing artwork, prerecorded video trailers, previews and the like, into the prerecorded video server storage system 103. All files are tracked with a relational database maintained by the manufacturing controller 107. In the preferred embodiment of the present invention, the data files are also encrypted to ensure security against theft. They may be encrypted as stored or may be encrypted before transfer to the retail outlet 20.

Manufacturing Server and Prerecorded Video Storage

A manufacturing controller and prerecorded video database 107 in conjunction with the prerecorded video storage facility 105 are the central components of the ability to provide prerecorded video on-demand. This system overcomes the inventory storage problem of current video outlets and video on-demand CATV head ends by utilizing the central repository in the prerecorded video storage facility 105 to store and dispense digital copies of prerecorded videos in an electronic form rather than then the current "hard copy" distribution system. The central repository and storage facility 105 enables the distribution of a very large number of popular prerecorded videos and hard to find titles currently unavailable to most video outlets and cable television distributors of video on-demand. This results in no product shortage (which can produce customer dissatisfaction) and no product surplus (which can produce profit erosion for the retailer) at the retail level. The prerecorded video storage facility 105 will also store prerecorded video previews, sell-through artwork, label data and database header information in a digital format for downloading with the prerecorded video to the retail level for generation of artwork when the prerecorded video is manufactured or for previews when the customer accesses the prerecorded video preview kiosks 123.

Prerecorded videos are transferred to the retail facility from the prerecorded video storage facility 105 using asynchronous transfer mode (ATM) protocol on an optical fiber network. The prerecorded video files are transferred

through an ATM OC-3 fiber to an ATM switch 113 locally which then transfers the files to the retail outlet over an ATM synchronous optical network (SONET) OC-12 fiber optic connection 127. The manufacturing controller 107 is also connected to the retail outlet through the ATM switch 113 using an ATM OC-3 fiber optic connection, and through the ATM synchronous optical network (SONET) OC-3 or OC-12 fiber optic connection 127.

Accounting and Transaction Engine

The accounting and transaction engine 109 of Figure 1 is also connected to the retail outlet and to the other components of the host status center 10 through an ATM OC-3 fiber through ATM switch 113. All accounting and transaction information is recorded by the accounting and transaction engine 109 which also has external connections to allow electronic money banking. The accounting and transaction engine 109 accounts for each transaction at the retail level including revenue accounting, customer demographic information database, support inventories and the retail outlet financial accounting. The system also collects and maintains identification and demographic data for each customer which would include, by way of example and not by limitation, the name, address, home telephone number, preferred contact procedure, major credit card number and historical use profile information. This information would also include product type, use, frequency, date and time information and payment schedules. A voice identification database is also an option in which a customer could identify themself at the kiosk 123 by voice identification with the voice print information stored in the accounting engine 109. An advantage of storing all customer data at the central site 10 in the accounting and transaction engine 109 is to provide the freedom for customers to visit any franchised retail outlet 20 across the entire geographic region serviced by the host data center 10. The customer would only need to register once and thereafter can visit any retail outlet 20 to rent or buy prerecorded videos.

Upon authorizing a transaction, the accounting and transaction engine 109 issues a unique transaction order number and controls the initiation of the requested transfer of the prerecorded video as well as payment of studio

royalties and the updating of an accounts payable database. The transaction engine 109 also updates all accounting records and bills the retail outlet for the transaction. By downloading information to the retail outlet, the accounting and transaction engine 109 can update the customer database which may also be held locally in the retail outlet manufacturing controller 121.

The accounting and transaction engine 109 also is capable of electronic funds transfer. Financial transactions between the retail outlets and the host data center and with the external prerecorded video studios utilizes direct electronic funds transfer 111 between the several accounts. The accounting and transaction engine performs account balancing on a daily basis including foreign currency conversion. Electronic funds transfer 111 is based on a fixed and pre-negotiated set of billing rates. The retail outlet may elect to offer the several products at higher or lower prices but may not change the fixed system billing rates.

The accounting and transaction engine 109 also monitors all accounts and can provide account summary and reports. With this facility, studios can monitor their individual financial data, sales results and promotion results from the retail level on a real time basis. In addition, the retail outlets shall be able to monitor their own financials on a real time basis. To facilitate the electronic banking, customer payments shall be either by means of major credit card or by cash transactions handled at the retail level.

The accounting and transaction engine 109 also monitors and facilitates sell-through product return and rental transaction closure. Upon a product return or rental transaction closure (rental return), the system updates the customer financial and demographic databases including all final or late charges. The inventory accounting databases are updated and the transaction is closed.

The system also employs computer and physical security features to protect the interest of the customers, the studios, the retail outlets and the host data center company. Transaction authorization codes, data encryption and prerecorded video specific passwords are included to provide additional security.

The system ensures that all customer information and demographic data is kept confidential unless the use thereof is specifically authorized by the customer.

Detailed Description of the Retail Manufacturing Center

The plurality of retail manufacturing centers 20 are, in the preferred embodiment, located in local communicates across a large geographic area such as the entire United States. The retail manufacturing centers 20 are connected to the host data center 10 through fiber optic links as described above. Those skilled in the art will readily recognize that alternate communication links are possible including satellite links and high speed wire connections.

The Decompression Engine

As described above, the digitized prerecorded videos are kept in an MPEG-2 compressed format in such a way as to facilitate parallel decompression at the manufacturing site. Figure 3 is a block diagram of the decompression engine 129 and those skilled in the art will readily recognize that the compression engine used in the video capture center 103 is an analog of this decompression architecture. Referring to Figure 3, the prerecorded video data file in its compressed, encoded and encrypted form is received from the ATM switch 125 over, in the preferred embodiment, a local ATM OC-3 or OC-12 fiber optic connection. The MPEG-2 decoder 129 receives the prerecorded video through an ATM network interface card (NIC) 301 as shown in Figure 3. This OC-3 fiber optic connection is typically operating at 155 megabits per second (mbps). The ATM NIC card 301 buffers and transfers this data to the input data router 303 where the format of the MPEG-2 data is broken into its corresponding video and audio components. The decompression board 305 receives the separate video and audio components and decompresses the information into a plurality of parallel video data streams and a plurality of audio data streams depending upon the type of audio format encoded such as stereo, surround sound and multi-channel audio. The output data router 307 directs the data streams of both video and audio components to the digital-to-analog converter 309 of the respective high-speed 40X VHS recorder where the individual data streams are converted from digital to analog signals for recording by the video and audio

heads, respectively. The decompression engine 129 may service one or several high speed recording devices. In the case of a video duplication center, a single decompression engine 129 may simultaneously send the reconstructed prerecorded video information to a plurality of high speed video recorders for mass duplication of prerecorded videos at 40x speed.

As described above, the decompression engine 305 may operate in one of two general architectures as shown in Figure 4. Since the 40X high-speed VHS recorders require parallel data streams to write eight tracks of video information simultaneously using a helical scan drum rotating 5 times the normal SP speed onto a videotape moving at 40 times the normal SP speed, the information must be received by the VHS recorder in a parallel format at a high speed. The parallel format used may be parallelized over time or over space as shown in Figure 4. The pictures or video frames depicted in 401 of Figure 4 show video frames numbered 1-9 which represent a plurality of video frames making up a moving picture. Those skilled in the art will readily recognize that the video frames may be of a variety of video formats such as NTSC, PAL, SECAM, and any variety of other variations on video formats. In essence, each of the video frames is sequential in nature in the prerecorded video format and likewise will be sequential in nature when recorded on a videotape.

In the preferred embodiment of the present invention, the decompression engine and its compression analog, compress and decompress the video frames in a parallel over time format 402. In this fashion, eight video frames are processed in parallel by each central processing unit of the decompression engine. As shown in block 402 of Figure 4, video frames 1-8 are parallel processed through CPU-1, video frames 9-16 are processed through CPU-2 and video frames 17-24 are processed through CPU-3, etc. In this fashion, when the video information is decompressed from the MPEG-2 format, eight frames of video are processed in parallel for parallel writing by the eight heads (16-gap pairs) helical scan recording head of the high-speed video recording devices described below.

In an alternate embodiment, the video information could be parallel processed over space as shown in block 403 of Figure 4. In this fashion, each video frame is divided into N segments, which in the preferred embodiment would be eight segments. Each of the eight segments would be parallel processed by one of eight CPUs. Each successive frame of video information would likewise be segmented into eight portions for parallel processing. In the preferred embodiment to the present invention, however, the parallel over time concept is preferred.

The general architectural design of the parallel processing of the decompression engine is shown in Figure 5. The MPEG-2 data stream received from the input data router 303 of Figure 3 is fed to parallel processing pipelines 501a, 501b-501n, generally referred to as parallel pipeline processor 501 and generally representing the decompression boards 305 of Figure 3. In parallel pipeline processor 501a, the MPEG-2 data stream receives frames 1-8 of the original video signal by CPU-1. CPU-1 of parallel pipeline processor 501a has a local store of approximately two megabytes of storage. Each of the parallel processors 501 have identical architecture but process different sets of video frames. For example, parallel pipeline processor 501b receives frames 9-16 of the MPEG data stream. Thus, when parallel pipeline processor 501a is processing frames 1-8 in a parallel fashion of the video information, pipeline processor 501b is also processing frames 9-6 to ensure that the data is available when needed for writing by the high-speed VHS recorder.

The decompressed parallel data streams for frames 1-8 of the MPEG-2 data stream as processed by CPU-1 of parallel pipeline processor 501a is fed to a memory controller 504a which contains a local store of 500 kilobytes of memory 505a. The memory controller controls the loading of frame buffer 506a with the decompressed video information for the eight frames of video data. Frame buffer 506a is capable of unloading eight frames of video information in eight parallel data streams operating at 552 megabytes per second for driving the high-speed VHS recorder through digital-to-analog (D/A) converter 309. The other parallel operating pipeline processors 501 of Figure 5

operate in a similar fashion such that when the video heads are ready for the next set of frames of data, that processor has already loaded its respective frame buffer 506 for unloading the data information to the high-speed recorder.

Figure 6 is a more detailed description of the parallel operation of the memory architecture of an individual parallel processing pipeline 501 of Figure 5. CPU 502 performs the data decoding and formatting of the compressed MPEG-2 data stream into an eight bit wide byte for each pixel of the video frame to be written. Those skilled in the art will readily recognize that each frame or picture of a video image is actually comprised of two fields of information. The fields are interlaced in the NTSC and PAL formats but are processed separately. Each pixel byte is decoded and sent to memory controller 504 where they are buffered for writing to the frame buffers. Memory controller 504 stores a complete field of information in memory 505 before transferring it to its respective frame buffers of frame buffer memory 506 where each field 601, 602, etc., stores a separate contiguous field of video. After a complete field is assembled into the frame buffer memory, the respective fields are transferred to the digital-to-analog (D/A) converters for writing to the respective write heads of the high-speed video recorder. Each of the 32 parallel operating pipelines of Figure 5 are identical to the architecture shown in Figure 6.

A detailed top-level architectural view of the decompression engine and its associated buffers of Figure 3 is shown in Figure 7. The parallel nature of the operation of the decompression engine is highlighted in Figure 7 by showing the parallelism of the decompression engines for video and audio channels. The ATM receiver 701 is connected to the OC3 data stream from the ATM switch 125. The ATM receiver serially transfers the information through transport buffer 702 to the transport processor 703. Microprocessor 704 operates with the transport processor to strip out vertical blanking information and text to be reinserted into the vertical blanking interval of the resynchronized video signal using the output controller 707. The transport processor 703 is supported by the phase locked loop circuit 705 which generates all timing signals for the system including system clock. The system clock signal synchronized with the

transport processor is fed to a timing generator 706 which provides overall system timing to all of the parallel processes to ensure that they operate in synchronization.

Figure 7 shows the parallel operation of the multiple decompression engines for the video information and also shows two sets of parallel pipeline processors for re-creating hi-fi audio and linear audio tracks for the videotape. The video parallel pipeline processors 305a-305n shown to the top of Figure 7 are as described above. Each of the parallel pipeline processors 305 include an FIFO buffer for receiving the serial information from the transport processor which is addressed to the specific pipeline which will decode the frames assigned to it. The serial information from FIFO buffer 708 is fed to the CPU 502 which passes the information to the MPEG-2 video decoder 7304 which corresponds to a portion of the memory control units 504 of Figure 5. The MPEG-2 video decoder 730 is an off-the-shelf part commonly available in the video industry. Here the information is decoded into video pixel data where the fields of each video frame are assembled in the frame buffer 506 which is also referred to as a group of pictures (GOP) buffer. This information is then placed in video channel buffers external to the decompression engines for delivery to a D/A controller before writing to the video heads. The video channel buffers are fed through a color under unit to place the correct chrominance information into the data stream for reproduction on the video recorder by the recording heads.

Due to the parallel nature of the present invention, the architecture of the hi-fi audio section and the linear stereo sections of the decompression engine shown in Figure 7 are very similar to the video pipeline sections shown to the top of Figure 7. The hi-fi audio is written onto a VHS videotape on top of the video information using a separate frequency carrier through the helical scan recording heads. Thus separate recording heads are used for the hi-fi audio information than are used for the video information on a helical scan VHS recorder. The linear audio or linear stereo audio information is written in a linear track on the edge of the videotape using linear record heads and thus the linear

audio information must be decoded separately from the hi-fi stereo information due to different frequency carriers.

The hi-fi audio decoder pipelines 711a-711n shown in Figure 7 each process the hi-fi audio for a particular series of video frames. The information is received and processed similar to, and in synchronization with, the video parallel pipelines except that an MPEG audio decoder is used rather than an MPEG-2 video decoder 730. The same type of MPEG audio decoder 721 is used in the linear audio pipeline processors 717a-717n with the timing of the linear audio also corresponding to the video frames being decoded and written by the video recorder.

Hi-fi channel buffers 723 receive the hi-fi channel information which will be written by the helical scan heads for hi-fi audio while the linear audio information is stored in the stereo channel buffer 725 to be written by the linear audio heads of the high-speed VHS recorder.

An even more detailed description of the video compression engine output section memory architecture is shown in Figure 8 for the video pipeline processors 305. Two of the parallel pipelines are shown but those skilled in the art will readily recognize how the description of Figure 8 may be extended to describe and encompass all the parallel pipeline operations and their synchronous control.

The output of an MPEG-2 video decoder 730a is fed to an address generator and data formatter to begin reformatting the frames of video information. Sixty-four bit wide data buses are used to transfer assembled video information to the output sections. The address generator and data formatter 801 separate the luminance and chrominance data from the data stream received from the MPEG video decoder 730. A luminance RAM memory 802a receives and stores the address and data information for the particular video field of information being processed at that particular moment. Concurrent with this operation, the chrominance information is stored in chrominance memory 803a for the same field of video information. Once assembled, these parallel frames of information are transferred via the luminance and chrominance data buses 804

and 805 respectively under control of the data transfer controller 806. This synchronous information is stored in pages of static random memory 807 and 808 for luminance information and 809 and 810 for chrominance information. This information is buffered and then processed by the digital-to-analog control circuit 811 which includes the color under processing and the vertical blanking interval text insertion functions. All this information is combined and passed as digital information to the separate luminance and chrominance D/A converters. The chrominance and luminance information in an analog form is combined for recording by the respective recording heads of the high-speed VHS recording device.

<u>40X High-Speed Writer Hardware</u>

The high-speed VHS writer records a standard NTSC or PAL VHS videotape into SP (standard play) speed at 40 times the normal speed. This recording includes hi-fi audio and linear audio tracks. Those skilled in the art will readily recognize that although in the preferred embodiment and in this detailed description of the preferred embodiment, an NTSC or PAL VHS system is described, the present invention is readily modifiable to other formats of helical scan recorders such as beta cam, eight millimeter, U-matic, one inch and other videotape formats.

The high-speed video writer hardware 115 shown in Figure 9 has a helical scan head 901 which contains 16 video and 16 hi-fi audio heads arranged as gap pairs such that there are eight gap pairs of video and eight gap pairs of hi-fi audio heads in contact with the tape at all times. Eight of each video and eight of each hi-fi heads are recording simultaneously. Each of the eight video heads records a different video field while each of the eight hi-fi audio heads record a different audio segment. The RF spectrum to the video and hi-fi audio heads is five times the normal speed whereby the linear tape speed is 40 times the normal tape speed. Linear audio recording recorded by the linear audio record head 902 is at 40 times the normal speed. The control track on the videotape is also recorded by audio control head 902 at 40 times the normal tape speed.

The servoelectronics subsystem 903 interfaces with the decompression subsystem 129 and the recorder controller 904 to synchronize the transfer of video and audio information to the helical scan head 901 and the movement of the tape 905 from cassette 906. The analog video processing circuitry 907 receives the eight parallel video frames as serial analog information from digital-to-analog converter circuit 309 to provide it to the eight record heads to simultaneously write eight frames of information at a time. In a similar fashion, the analog audio processing circuitry 908 receives eight hi-fi audio analog signals in parallel for placing the hi-fi audio information on the audio subcarrier for writing by the eight hi-fi audio heads of the helical scan head 901. Also, analog audio processing circuit 908 receives the linear audio tracks at 40 times the normal speed for writing the audio information through to the videotape 905 via audio head 902.

Figure 10 is a more detailed diagram of the operation of the high-speed recorder 115 of Figure 9. The helical scan write head 901 contains eight gap pairs for hi-fi audio and eight gap pairs for video recording in which only eight record heads for video and eight record heads for hifi audio are in contact with the tape at any given moment.. A video record head 1001 shown in Figure 10 is simultaneously writing a field of video information at the same time that video head 1002 is also writing. The frequency at which these heads are writing information is five times the normal carrier frequencies for encoding the analog information onto the videotape 905. Head 901 is carefully machined and angled such that the correct azimuth angle of the information recorded on tape 905 corresponds to the azimuth angle required for playback at normal speeds. Careful control of the tape speed is accomplished through servoelectronics 903 to ensure compatibility with playback of the recorded information at standard speed on a standard VHS videotape player.

Figure 11 is a detailed view of tape 905 showing the video fields and audio fields recorded on the tape with the eight simultaneously recording heads. The video heads are shown in the lower half of Figure 11 with the approximate relative location of the recording heads on the helical drum 901 in

order to simultaneously write the eight fields of analog video information simultaneously. Each frame of video information is actually made up of two fields of interlaced information which are separately written on the videotape 905. This interlacing is part of the NTSC and PAL video standards. The information written onto the videotape corresponds to these video standards and corresponds to the VHS standard for azimuth angle, carrier frequency and tape speed on normal playback.

Video recording head 1001 records onto field 1 shown on videotape 905. Video head 1002 records field 2 onto videotape 9005 and the remaining heads record as shown in Figure 11. Those skilled in the art will readily recognize that hi-fi audio information (not shown) is recorded on top of the video information on a standard videotape 905 using a different carrier frequency and different azimuth angle so as to not interfere with the video information recorded beneath the audio information.

The relative locations of the video record heads 1001-1008 are also shown as they appear during normal tape travel on videotape 9005. The actual track angle 1009 of the tape heads on helical scan record head 901 is shown by example on the tape 905 at 1009. The linear audio tracks 1010 whether they are stereo or monaural are recorded at 40 times the normal speed and are recorded at the standard location 1010 at the top of videotape 905. Also the control track 1011 containing synchronization information for facilitating proper playback of the video information is placed at the standard location 1011 at the bottom of videotape 905 as shown in Figure 11 and is also recorded as described above at 40 times the normal speed.

Figure 12 shows the normal NTSC VHS spectrum on the tape for recording the chrominance, luminance and hi-fi audio information. The standard chroma carrier with sidebands is located at 0.629 megahertz, the hi-fi audio left and right channels are recorded at 1.3 to 1.7 megahertz, while the center luminance carrier deviates between 3.4 and 4.4 megahertz. In order to write the normal VHS spectrum on the tape at five times the normal recording speed, the carriers must be recorded at five times the normal frequency so that the playback

is according to the frequency spectrum required in Figure 12. This enhanced frequency spectrum is shown in Figure 13.

Figure 13 shows the high-speed spectrum as recorded onto the tape. In this fashion, the chroma carrier for color under with sidebands is centered at 3.1 megahertz, the left and right hi-fi audio carriers are located at approximately 7.5 megahertz and the center carrier for the luminance information is elevated to 20 megahertz. These, of course, are the recording speeds shown in Figure 13, however, since the information is written at five times the normal speed, the playback will exhibit the frequency spectrum shown in Figure 12 when the tape speed is played back at normal SP speed.

The present system may operate with different video standards without departing from the spirit and scope of the present invention. Digital videotape, for example, may also be written with the present invention by directly writing the digital video information rather than placing it on chroma and luminance subcarriers. Digital video disk information may also be directly written in a high-speed fashion using the concepts of the present invention with the decompression engine.

Included in the tape handling for the high-speed recorder 115 are additional tape heads to clean and polish the tape to allow refurbishing and re-use of tapes returned from rental. A cleaning wiper removes loose dirt, oxide and other debris to clean the tape to assist in removing any temporary dropouts. In addition, a burnishing tape is used to polish the surface of the videotape for improving the videotape surface for high-speed recording.

Another feature of the present invention is the tracking of tape rental and sell-through information by direct recording of relevant information onto the header or trailer of the videotape in the control track or audio track using linear record head 902. Information recorded are items such as the number of times the videotape has been used, the person who has rented the videotape and a history of its re-use. This information can also facilitate copyright control and tracking of counterfeiting since this information would inadvertently be copied onto the next videotape copy providing a trail to the origins of the

counterfeit copies. Those skilled in the art will readily recognize that the vertical blanking interval of the video signal could also be used to record such information.

In order to record at such high frequencies shown in Figure 13, each write pair head is required to be spaced at six millimeters maximum spacing. The tape moving at 29 meters per second with a scanner head diameter of 64.40 millimeters at a tilt of 5°42'27". The specifications for the high-speed recorder compared to a normal-speed recorder are shown in Table 1.

TABLE 1: Specifications for the High Speed Video Writer

	Normal Speed	High-Speed
Linear tape speed	1.31 ips (33.35 mm/s)	52.4 ips (1.334 m/s)
Writing Speed	228.5 ips (5.8 m/s)	1201.6 ips (30.51 m/s)
Bandwidth	129 KHz to 7 MHZ	678 KHz to 28.9 MHZ
Octaves	6	6
Luminance BW	3.4 to 4.4 MHZ	17.87 MHZ to 23.13 MHZ
Chrominance BW	129 KHz to 1.5 MHZ	678 KHz to 5.78 MHZ
FM auto. subcarrier	(L) 1.3 MHZ (R) 1.7 MHZ	(L)6.8 MHZ (R)8.9 MHZ
Scanner rotation	1800 RPM	9,000 RPM
Scanner tilt	5° 56' 7.4	5° 43' 12"
Scanner diameter	62 ± 0.01 mm	67.636 mm
Number of heads	4	32
Head spacing	48 mm	6 mm
Video head spacing	180°	22.5°
Audio head spacing	180°	22.5°
Transformers rings	4	16

Since the tapes are recorded numerous times (up to 500 uses) and a normal cycle for a tape is to record and then play between one and ten times, the tapes need to refurbished between each use. The tape quality is assessed prior to recording by inspecting the tape at high speed before erasure. An

optoelectronic detection system locates edge damages, wrinkles, creases in the tape, inspects for surface damage and the like. To make the refurbish and re-use system more efficient, the customer is requested not to rewind the tape upon last use so that the recorder subsystem 115 can rewind the tape and inspect it simultaneously. Along with the inspection, the tape can be cleaned and refurbished using the aforementioned refurbishment drum and wiping fingers. If upon rewind, the electro-optical inspection system detects damage beyond a preselected threshold, the tape is discarded.

In the preferred embodiment, the tapes used with the present system may be standard high quality video tapes available from a variety of manufacturers. Those skilled in the art will readily recognize that video tape specially constructed to survive the rough handling required by the 40X tape writing subsystem 115 may be advantageous to extend the useful life of rental tapes. In a specially construct video tape, the cassette shell is modified to improve the strength of the hubs, the upper and lower hub flanges, the tape guides and the shell could include a special cassette identification hole to distinguish it from standard VHS cassettes. The tape formulation may also include an improved binder, improved magnetics and improved surface quality.

The individual video data and analog information paths are shown in Figure 14 for the eight video heads described in Figure 11. The eight bit chrominance and eight bit luminance information is received from the MPEG-2 video decoders and demultiplexed into the appropriate field and frame information as shown in Figure 14. The demultiplexing and digital-to-analog decoder section 1401 shown in Figure 14 corresponds to the output data router 307 and D/A converter section 309 as shown in Figure 3. The 27.2 megabit per second chrominance signals and the 34.5 megabit per second luminance signal for each video head are demultiplexed and sent to digital-to-analog converters to produce the analog luminance and chrominance signals for writing by each videotape head. The luminance and chrominance information, of course, is modulated according to the carriers described in Figure 13 by a video modulation section 1402. The luminance carrier information is processed by

analog processing circuit 1403 and modulated using FM modulator 1404 to produce the 20 megahertz FM luminance carrier signal for the video head. The two chrominance signals with side band information are processed by a chrominance analog processing circuit 1405 and are quadrature modulated through quadrature modulation circuit 1406 to produce the chroma carrier color under signal. The chrominance and luminance carrier signals are combined by signal combiner 1407 and the resultant signal is fed to the appropriate video head for recording by the helical scan record head 901. This signal path shown in Figure 14 is duplicated for each of the eight video heads. A similar system is used for the hi-fi audio information.

Robotic Tape Handling Cabinet

A plurality of high-speed video recorders 115 can be combined into a single robotic cabinet 1501 shown in Figure 15. A VHS tape inventory 1502 contains in the preferred embodiment 500 tapes in a storage cabinet with a robotic mechanism for loading and unloading any one of the tapes from any one of the plurality of high-speed recorders 115. The robotic cabinet 1501 is controlled through an RS232 interface by the retail outlet manufacturing controller 121. Many of the tapes contained in robotic cabinet 1501 have been previously recorded with popular prerecorded video titles and hence do not need to be re-recorded if a customer requests the identical title. If once recorded with a popular title of a recently released movie, and returned by a customer, the tape is first checked and refurbished in one of the high-speed recorder units 115 and then stored in an unerased form in robotic cabinet 1501 for later re-rental to a second customer. A pre-recorded video tape may be overwritten by the high speed video recorder 115 by incorporating flying erase heads on helical write drum 901.

The manufacturing server 117 with the prerecorded video cache is also connected through the ATM switch 125 to one or a plurality of high-speed recorders 115 for manufacturing a videotape. In such a case, a blank video cassette is removed from the tape inventory by the robotically controlled mechanism to load the tape into one of the plurality of high-speed recorders 115

for manufacture of the requested title. In the preferred embodiment, the resulting recorded VHS NTSC tapes meet the industry standard requirements as specified in SMPTE and ANSI document number V98.32M and SMPTE RP 142 and 148.

High Speed Recorder Transport Mechanism

The high speed VHS recorder 115 is designed to operate at frame rate of approximately 1200 Hz. The high speed VHS recorder 115 is based upon a commercially available Panasonic AG6850 VHS Hi-Fi duplicating recorder. This is a special recorder used for round the clock duplication operations for producing commercial videotapes. The record heads as described in the specifications given in Table 1 will operate at 9000 RPM and are of a different size than the standard VHS record heads. The capstan and pinch roller assemblies are replaced by capstan and pinch roller assemblies found in the Panasonic DS840-850 VHS broadcast studio machine which is designed to move tape at up to 32 times normal speed.

Although some of the mechanisms of the aforementioned Panasonic recording devices can be used in the preferred embodiment of the present invention, a wholly different helical scanned recording head is required. A helical scan recording head is made up of a lower drum and upper drum with a machined tape guide "fence" machined into the tape drum at the helix angle of 5° 43 minutes 12 seconds. The lower drum contains the bearing assembly with two sets of pre-loaded duplex ball bearings on the outer surface of the rotor shaft. The rotor shaft is hollow and contains sixteen pairs of wires connected to the eight head pairs of the recording drum. The sixteen pairs of wires run to a capacitive coupler having 16 rings with inter-ring shielding transfers.

Sixteen record amplifiers are required to drive the 16 record heads on the rotor. The record amplifiers with an operational bandwidth capable of handling both the color under signal and the luminance signal. The inductance of the record head is configured for recording to 35 MHz.

The capstan servo speed moves the tape at a nominal speed of 1.334 meters per second when recording. In bringing the tape up to 40X speed for recording, an acceptable short unrecorded header of about 1 foot of tape is

generated during the acceleration period. This rapid tape acceleration is implemented under control of the capstan, and by a supply reel servo feeding tape to the cylinder. The supply reel servo's input signal is derived from a tape tension measurement in the tape path, and the tape take up is maintained stable by means of a take up reel servo slaved to the supply reel servo. To protect the edges of the tape, the high speed scanner is not rotating during insertion of the cassette and the wrapping of the tape around the cylinder during loading. Hence, initially there is no lubricating air film between the tape and the cylinder until the scanner (helical scan drum) begins to rotate. The supply and take up servos provide the controlled forces required for rapid acceleration of the tape against the friction forces resulting from the wrap around the fixed cylinder.

The helical scan write cylinder uses a higher powered motor to overcome the higher inertia required for a larger and heavier write cylinder head. The servo controller 903 shown in Figure 10 controls the helical scan write head 901 by taking the frame synchronization signal from the decompression electronics and dividing it down to use as a phase control signal to control the servo accurate enough to control the speed of the write heads at five times normal speed.

At standard VHS speed, edge track audio recording employs a bias frequency of 60 kHz and the 60kHz signal is also used for tape erasure by means of a full tape width erase head. In the 40X recorder, the audio bias frequency is 2.4Mhz, and energy considerations preclude the use of the high frequency bias oscillator signal as the erase signal. Instead, a separate oscillator signal, within the frequency range of 180kHz to 400 kHz, is used for erasure. Prior to the start of video and audio recording, e header containing administrative information may be recorded on the edge audio track using FSK (frequency Shift keying) as the coding means.

The control track is recorded using a head with an inductance of approximately 1 mH, providing a rise time of 5 microseconds in recording the control signals.

<u>ATM Switch and Communications Network</u>

The present invention, both in the host data center 10 and in the retail manufacturing site 20, require high bandwidth communications of a reliable nature. Fiber optic communication is used throughout both sites in the form of a synchronous transfer mode (ATM) network. Between the host status center 10 and the retail site 20, a commercial fiber optic long line communication connection is used between the ATM switches as shown in Figure 1. For example, the present invention uses a data stream of 155.52 megabit per second to transfer the MPEG-2 data stream representing the compressed movie. In the preferred embodiment of the present invention, standard off-the-shelf ATM network interface cards are used to provide the required rated speed between commercially available work stations and personal computers. These types of off-the-shelf ATM network interface cards are available from such companies as Adaptec, Fore Systems and Efficient Network Solution.

All of the components shown in Figure 1 communicate with one another using the ATM fiber optic network through ATM NIC card interfaces and OC-3 optical cabelling between the locations. The dedicated servers of Figure 1 are commercially available personal computers operating at the highest commercially available speed. For example, the prerecorded video cache server 117 is a dedicated superserver available from such companies as Digital Equipment Corporation or other vendors with a large array of disk drives for storage of the four gigabyte prerecorded video files in the local cache. The disk drives of the server 117 could be of a variety of types including SCSI RAID drives commercially available and known to those skilled in the art.

<u>Prerecorded video Preview and Selection Kiosks</u>

The prerecorded video kiosks of Figure 1 are available to the customer for new customer registration, customer sign on, video trailer preview, video rental and video sell-through. Each retail outlet 20 will support from one to twenty kiosks. The kiosks are used by the customer using touch screen technology for ease of use. Each kiosk is interfaced to the host data center 10

through the manufacturing controller 121 over the ATM network. The kiosk screens in idle mode will display graphic advertisements, talking head information, and may cycle through different prerecorded video trailers. Should a customer wish to access the kiosk, the customer can touch the screen to activate a login procedure. The customer may either enter a new customer information screen or enter his or her existing PIN number to go right to the video category selection screen.

The prerecorded video kiosk can display prerecorded video selections within categories or based on new release date or even a personal preference screen based on the data entered when the customer initially registered with the system. A personal preference screen can be invoked by the user to either search and select prerecorded videos of their particular tastes or request suggestions based upon their statistical past history of selections.

The kiosk is capable of displaying a search screen to locate prerecorded videos based upon a fuzzy logic search criteria to assist a customer locating a prerecorded video based upon some obscure references. Upon selection of a prerecorded video to purchase or rent, ordering information, pricing a sales window will appear in which the purchase can be completed and the manufacturing of the prerecorded video initiated. In addition, the kiosk can be used to preview 30 to 60 second prerecorded video trailers of the prerecorded video selected for potential purchase or rental.

Each of the kiosks are implemented using a Micron® 100MHz P5 processor equipped with 16 megabytes of memory. The touch screen display as in the preferred embodiment is 640 x 480 SVGA true color monitor driven by a 640 x 480 SVGA display adapter operating at 16 million colors. A 16-bit stereo adapter is also part of the hardware specification along with a 32 bit MPEG-2 decoder adapter for decoding and displaying the prerecorded video trailers. The prerecorded video trailers and video trailers (short programs used to sample the product) stored at the host data center are not normally stored as compressed and parallel encoded prerecorded videos (such as the full length prerecorded videos that are needed for parallel recording of the highspeed VHS recorder 115).

Instead, the trailers are in a ready form for display by the kiosks and hence do not require the type of 40X parallel decompression used for the full length movies.

The operating system in the software specifications for each kiosk are based upon a Merlin® OS2 system with a software based upon IBM VisualAge® C++ using object oriented methodology. The software includes external libraries including the warp kernel tool kit and the IBM C++ multimedia development suite. The kiosk application software uses the IBM open class profile for parameter support during application and initialization. A single parameter initialization file, MVSPINIT.INI is used by the Kiosk application and subsystem software including database and network support libraries. Table 2 is a description of the kiosk application layer with a software layer described in a hierarchy.

Table 2: Kiosk Application Software Layers

Kiosk Application MVSKIOSK.EXE		
Communications Library MVSATM.DLL		Database Library MVSDB2.DLL
VisualAge Open Class Libraries DDE4XXXX.DLL		
Kiosk Parameter Initialization File MVSPINIT.INI	Talking Head MPEG-2	Video Database MSVSIDEO.DBF

Figure 16 shows the kiosk process and database flow. The kiosk application starts by reading the MVSPINIT.INI file for parameter initialization. A simple network interface test is executed in the beginning of initialization to ensure that all support libraries are loaded and operational and the network is available. The network test is limited to communication with the retail manufacturing controller 121 which maintains a visual status of all kiosk activity. As described above the kiosk normally operates in an idle mode

waiting for a customer interaction. When a customer begins interacting with the kiosk, the kiosk may use touch screen or voice recognition to provide input from the customer to the kiosk. The kiosk communicates with the customer using a talking head MPEG-2 video as shown in file 1603 of Figure 16 to provide directions and instructions to the customer.

A local store of the video database with all available prerecorded videos 1601 is kept locally on the kiosk and updated periodically by the host status center 10. The kiosk process 1604 interacts with the database library 1605 to provide search capabilities and information regarding all prerecorded videos available for purchase or rental. In the preferred embodiment of the present invention the talking head video is in a smaller quarter screen window with a resolution of 352 x 240 at a 3.9 megabit per second sample rate.

Figure 17 shows the operation flow of the retail outlet. The retail outlet manufacturing controller 121 operates as the central controller for the entire retail system at this site. As shown in Figure 17, more than one manufacturing server 117 maybe controlled by the manufacturing controller 121 there by facilitating modular growth based upon customer demand.

Upon sign-in on a kiosk 123, the customer's request is transmitted through the local ATM switch 125 to the retail manufacturing controller 121. The information is held in a queue at the retail manufacturing controller 121 and a customer inquiry request is sent to the host manufacturing controller 107 over the ATM switch 125. At the host manufacturing controller 107, the customer database is queried and the customer information is validated including, by way of example, checking for outstanding credit information and outstanding balances. By keeping the customer database at the central host manufacturing site 10, customers may register in any one video retail outlet 20 and be able to use any other of the plurality of video retail outlets in any other part of the world as long as the customer is registered at the central site 10.

At the kiosk 123, the customer can search for prerecorded videos on title, director, actress, actor, scene etc. The customer is allowed to preview the prerecorded videos and to order the prerecorded videos for rental or sell-

through. If the customer requests a preview of the movie, that request will go to the retail manufacturing controller 121 and the retail manufacturing controller makes a determination whether the preview is kept locally in the cache of the store or wether it needs to be downloaded from the host data center 10. If the preview is kept locally, the manufacturing controller 121 supplies the prerecorded video trailer or preview information to that particular kiosk were it is buffered and played simultaneously. If the prerecorded video preview is not kept locally, the retail manufacturing controller 121 will send a request back to the host data center 10 to the host manufacturing controller 107 to download the prerecorded video trailer from the host content servers 105. Once the preview is available, the customer can preview the movie.

If the customer places an order to rent a prerecorded video at the kiosk , all information regarding the transaction is transmitted to the retail manufacturing controller 121. Before manufacturing can take place, however, the cash transaction must be completed either through credit card, check or cash. To prevent fraud or to prevent needless wasteful manufacturing, the transaction is first completed and then the prerecorded video is manufactured for rental or sell-through.

The manufacturing of the prerecorded video begins by transmitting a request-to-manufacture to the host data center 10 where the host manufacturing controller 107 sends a query to the accounting and transaction engine 109 to determine if the studio has granted authorization to manufacture this particular video. For example, this video may be a new release that may already be in storage but has not been released to the public at this point in time. If the prerecorded video is available for rental or sell-through, the host manufacturing controller 107 will issue an authorization to manufacture the prerecorded video which goes back to the retail manufacturing controller 121 through the ATM network and switches 113, 127, 125.

After authorization, the retail manufacturing controller 121 will determine wether the prerecorded video is on local cache storage or if it must be downloaded from the host data center 10. If the prerecorded video already exists

on local storage, the retail manufacturing controller 121 will then cause the manufacturing server 117 to begin the manufacturing process. The remote manufacturing controller 121 will cause the cassette robotics cabinet to either locate the prerecorded video if it has already been recorded and available or it will load a blank cassette into one of the many highspeed VHS writers which is not busy at the time. Once the high speed writer is loaded with a tape and positions the tape to begin recording, the retail manufacturing controller 121 causes the manufacturing server 117 to begin recording the tape at forty times its normal speed. When the manufacturing is complete, the high speed recording device will send an acknowledgment back to the manufacturing server 117 indicating that the recording was completed successfully. This acknowledgment is then forwarded to the retail manufacturing controller 121 that the manufacturing is completed successfully.

Simultaneous with the cassette manufacture, the retail manufacturing controller 121 may print any cassette artwork that is needed and can be placed on the shell of the cassette or on the packaging. This packaging is printed with a color artwork printer 119 and hand assembled by the operator at the point of sale. Once the prerecorded video is placed in the artwork shell, the tape is handed to the customer and the transaction is complete. A receipt of the transaction is printed on receipt printer 131.

The retail manufacturing controller 121 sends a message to the host manufacturing controller 107 that this transaction has taken place. The financial transaction cycle is not complete however since the issuance of the tape to the customer is only one half of the financial transaction cycle. Several days later the customer will return the prerecorded video to the store where it is inserted back into the robotic cabinet and the high speed VHS recording device reviews the header or trailer information off the tape to insure that the correct tape was returned by the customer. Once verified, the customer information database is updated that the tape was returned correctly or that the tape was returned late or the wrong tape was returned. As the tape is rewound, the tape can be refurbished by the high speed writer and once rewound loaded back into

the robotic storage cabinet. After the tape is properly verified and returned to the robotic cabinet, the retail manufacturing controller 121 will send a network message back to the host manufacturing controller 107 indicating that the customer returned the tape on time or late which completes the full financial transaction.

System Transaction Flow

Figure 18 is a diagram of a financial transaction flow of the present invention for the purchase or rental of a prerecorded video and Table 3 is listing of the transaction types used with the present invention.. A customer transaction begins at the kiosk 123 with the customer ordering a prerecorded video to purchase or rent by pressing the generate or manufacture key. At this point, payment verification is initiated with a cash or credit card deposit within the retail outlet cash register. When the cash is received, cash voucher transaction data will be appended to a transaction packet termed "Transaction 01". The Transaction 01 information is sent from the point-of-sale retail transaction engine 121 to the accounting system transaction engine 109 at the host data center 10. If the customer is paying by credit card, the accounting transaction engine 109 initiates a credit verification transaction to the customer's banking system. In this case, an external interface is utilized (not shown) which verifies credit card transactions by modem as is known to those skilled in the art.

After the Transaction 01 has been received and verified by the accounting system transaction engine 109, the request to manufacture a tape is granted and a "Transaction 02" type packet (authorization to manufacture a tape) will be generated by the accounting system transaction 109. As described above in the case of a rental, this entire financial transaction will not be closed or completed until the prerecorded video cassette is returned to the inventory at the retail outlet 20. Receipt of the returned prerecorded video tape will generate a system transaction 08 which will close the entire transaction cycle. Once a transaction is closed due to the return of the tape, the information contained in the current transaction database 1808 is transferred to the archived transaction database 1802.

Other types of transactions may take place within the system shown in Figure 18. For example, a system "Transaction 05" will allow adding and changing information within the customer database and may be executed from the kiosk 123. Any deletion activities within the customer database requires a specific customer request. All of the aforementioned transactions are executed as a normal online activity between the point-of-sale retail transaction engine 121 and the accounting system transaction engine 109.

Other types of transactions take place within the system as secondary priority items which are run offline so that the information flow between the accounting system transaction engine 109 and the point-of-sale retail transaction engine 121 are not burdened with these types of maintenance transactions. Thus, these secondary system transactions are run in a batch mode. Examples of secondary system transactions are Transaction 07 for evaluating and calibrating the hardware platforms and software systems in execution at the host data center and retail outlet and including the kiosks 123. This transaction type measures all events occurring within the system and the connecting networks by measuring traffic, data flow, down time, etc. to assist in maintenance of the system.

A system "Transaction 10" is used for the transmission of studio royalty payment information 1804 to the copyright holders of the respective prerecorded videos manufactured at the retail outlet. This information can be updated on a daily basis, or more often if necessary, to provide the studio with detailed information of royalty dollars, transaction information and demographic information about the rentals.

Other types of batch and control reporting 1803 are generated by the accounting system transaction engine 109 using secondary transactions 03, 04 and 06 to generate reports on the activity within the system.

Table 3

System Transaction Types

Transaction Number	Transaction Description

01	Request to manufacture a tape for purchase or rental
02	Authorization to manufacture a tape
03	Studio database maintenance such as add, change or delete
04	Prerecorded video database maintenance for adding, deleting or changing a trailer, preview, artwork or labels
05	Customer database maintenance for adding, changing or deleting
06	General ledger maintenance for adding, changing or deleting
07	Hardware/software diagnostics
08	End of transaction life cycle for a tape
10	Studio royalty payment information

Redundancy is built into the system by ensuring that the archive transaction data 1802 and the current transaction data 1801 of the host data center 10 is duplicated at the retail outlet in the archive transaction database 1805 and the current transaction database 1806.

<u>Prerecorded Video Data Flow</u>

The prerecorded video data flow throughout the system is shown in Figure 19. In the preferred embodiment of the present invention, it is estimated that at least 80% of the prerecorded videos requested locally at the retail outlet 20 will be held locally in the cache disk storage of the retail manufacturing servers 117. As shown in Figure 19, multiple retail manufacturing servers 117A, 117B, etc. may be located at a retail manufacturing outlet 20 to service a higher volume of prerecorded video manufacturing. It is envisioned that the prerecorded videos held locally will be held on rotating mass storage using the RAID 0 standard with a fast ultraSCSI interface to the manufacturing server 117. When held locally, the prerecorded video is downloaded through the retail ATM switch 125 to one of a plurality of high-speed decompression engines 129 connected to a high-speed 40X VHS writer 115. The connection between the retail manufacturing server 117 and the high-speed decompression engine 129 would be through fiber optic OC-3 or OC-12

connections. In an alternate embodiment, Ultra SCSI connections direct from the retail manufacturing server 117 to the high-speed decompression hardware 129 could be used instead of the ATM network.

By holding most of the requested prerecorded videos locally, the amount of traffic over the ATM SONET connection 127 to the host data center 10 is reduced. The single retail manufacturing server is capable of providing prerecorded video data files to up to four high-speed writers simultaneously with unique prerecorded video files. Thus, the configuration of Figure 19 lends itself very well to the mass duplication market in which a single release is to be manufactured by a plurality of videotape writing machines. Thus, the configuration of Figure 19 is well suited for the mass duplication market.

Figure 20 shows the manufacturing server operation and the prerecorded video data flow when the prerecorded video is not held locally in local cache storage. Referring to Figures 19 and 20, the VHS cassette duplication will start when the remote manufacturing server 117 receives a request packet indicating that a "start duplication" command is received. Included in the request packet will be the content serial number (prerecorded video file name) and destination ATM address of the physical high-speed writer. The remote manufacturing server application will begin the transfer of the information of the MPEG-2 file containing the digital information for the prerecorded video to be manufactured from the MPEG-2 content SCSI RAID-0 disk drive to the ATM NIC OC-3/12 card via the Ultra SCSI RAID interface. The prerecorded video is then delivered to the retail outlet 20 via the SONET ATM vendor 127 via OC-12 fiber optic connections.

The prerecorded video is received at the retail outlet 20, at the retail ATM switch 125 where it is transferred via the ATM NIC OC-3/12 card 117 where it is stored in the MPEG-2 content disk array in a striped RAID-0 format via the Ultra SCSI RAID interface. Once the prerecorded video is downloaded from the host manufacturing server 107 to the remote manufacturing server 117, manufacture of the prerecorded video is performed as though the prerecorded video were always held locally in cache disk storage.

In an alternate embodiment, the prerecorded video can be manufactured directly from the host manufacturing server 107 without the intervention of the remote manufacturing server 117. In this embodiment, the MPEG-2 prerecorded video file is received from the host data center through the retail ATM switch 125 at the retail outlet 20 where it is immediately transferred to the high-speed VHS writer 115. The data file is received by ATM NIC OC-3/12 card 301 where the MPEG-2 file is immediately decompressed in a parallel format by decompression engine 129 for writing onto the VHS cartridge and tape assembly.

Redundancy of communication connections within the system is necessary to prevent the entire system from going down should the host data center be unavailable for any reason. For example, if the ATM SONET connection 127 between the host data center 10 and the retail outlets 20 is unavailable for any reason, alternate means of transferring transaction information and data are available such as land-based telephone lines. Land-based telephone lines may be too slow to transfer the four gigabyte MPEG-2 prerecorded video files, however, since a large number of the prerecorded videos to be manufactured are located at local cache storage, the retail outlets are still able to function as long as the financial information can be transferred between the accounting and transaction engine 109 of the host data center 10 and the retail outlet manufacturing controller 121 of the retail outlet 20. This is accomplished by having alternate RS-232 or dial-up telephone connections as shown in Figure 1.

In another alternate embodiment, the local retail outlet 20 can be authorized to manufacture a certain number of prerecorded videos locally if the communication channels between the retail outlet 20 and the host data center are down. Since 80% of the prerecorded videos are still available in local cache memory, the retail outlet could manufacture up to a limited number of prerecorded videos without having direct electronic connection between the retail outlet manufacturing controller 121 and the accounting and transaction engine 109. This, of course, would be limited by constraints such as fraud

prevention and copyright royalty avoidance problems. Once the retail outlet is back on line, the transactions could be batched and sent to the accounting and transaction engine 109 from the retail outlet manufacturing controller 121 to bring the two systems back into synchronization. Thus, once the communication is re-established, the archive transaction database files 1802 and the current transaction database files 1801 of the host data center 10 are synchronized with the archive transaction database files 1805 and the current transaction database files 1806 of the retail outlet 20 as shown in Figure 18.

Video on Demand

The present invention is readily adaptable to a video-on-demand architecture as shown in Figure 21. The host manufacturing center is as described in Figure 1 but in addition to the retail outlets 20 of Figure 1, separate ATM switches and local or regional service centers could be established for providing real-time video-on-demand feeds to homes, businesses, offices, libraries and the like. For example, a local or regional service center 2101 contains the equivalent of a retail outlet manufacturing controller 121 to interface with the manufacturing controller 107 of the host data center 10. Prerecorded videos requested from a home 2104, a business 2105 or a school library 2106 could be downloaded to local cache memory within the server 2101 and delivered to, for example, the home 2104 via an ATM fiber optic connection, standard cable or twisted pair wires, depending on the necessary bandwidth needed for real-time viewing of video. The same connections could be made between the service center 2101 and the business 2105 or the school library 2106.

In an alternate embodiment, a cable head end could provide video on demand to subscribers 2107 by having the equivalent of the retail outlet manufacturing controller 121 and the VHS manufacturing server 117 within the cable company infrastructure 2102 as also shown in Figure 21. Prerecorded videos are delivered to the cable head end 2102 from the manufacturing controller 107 for real-time playing over a dedicated channel at the subscriber's location 2107, being delivered by fiber optic cable or standard CATV cable.

In yet another alternate embodiment, a regional bell operating company such as a local telephone company could also have the equivalent of a retail outlet infrastructure 20 within the RBOC (regional bell operating company) infrastructure 2103 for the delivery of video on demand to the subscriber location 2108, also shown in Figure 21. Once again, the RBOC infrastructure 2103 operates similarly to the retail outlet 20 in completing transaction orders and delivery of video on demand to the subscriber 2108.

Manufacturing Server Operation

Referring to Figure 20, the VHS cassette duplication will start when the remote manufacturing server 117 receives a request packet indicating that a "start duplication" command is received. Included in the request packet will be the content serial number (file name) and destination ATM address of the physical high-speed writer. The remote manufacturing server application will begin the transfer of the information of the MPEG-2 file containing the digital information for the prerecorded video to be manufactured from the MPEG-2 content SCSI RAID-0 disk drive to the ATM NIC OC-3 card via the Ultra SCSI RAID interface.

Mass Duplication Environment

The present invention in an alternate embodiment is designed to distribute and manufacture on-demand full-length prerecorded video (such as movies, TV programs, information tapes, music videos, sporting events, infomertials, educational videos, and the like) to a plurality of mass duplication machines in a manufacturing environment. The video duplicators may be real time, or high speed duplicators.

Figure 22 is a block diagram of a manufacturing environment according to an alternate embodiment of the present invention. The environment of Figure 22 is most typically described as a duplication center in which a plurality of video duplicating machines equipped with decompression engines are attached to ATM switch 125. These duplicating recorders 2201a-2201n receive the MPEG-2 files from the video and customer data base 107 of the data center 10. The MPEG-2 digital data files containing the prerecorded video is fed

to the plurality of recorders 2201 in order to produce the same prerecorded video content simultaneously on all recorders 2201.

The duplication machines 2201 may or may not be synchronized for writing. In an alternate embodiment of the present invention, the duplicator machines 2201 are not perfectly synchronized and in fact can be duplicating different prerecorded video content on different machines 2201. However, in this alternate preferred embodiment, the duplicating machines 2201 have spindle synchronization such that the take-up reel and feed reels of the VHS machines are servo controlled so that all duplicators will be operating at approximately the same point along a prerecorded video being duplicated. These duplicators will be synchronized at any speed between real time and 40X speed.

The high-speed duplicators in a physical embodiment would be mounted in 19-inch rack mount stacks. Robotic mechanisms like those described above can feed, load and unload tapes as required for the duplicators 2201. The racks may contain 10 machines or more with up to 500 or more racks being fed by ATM switch 125. In this fashion, the prerecorded video is received in a digital format from a host data center 10 (locally or remotely located) in which the MPEG-2 data is sent through ATM switch 125 to recorders 2201.

In a factory environment, real time or normal speed duplicators may be used. The duplicator machines 2201 may be high speed duplicating VHS machines as described above. In an alternate embodiment, the duplicating machines 2201 may be real time commercially available duplicating VHS writers, DVD writers and the like. Real time duplicating VHS machines used in a commercial duplication or factory environment are known and available. For example, these types of machines could be of the variety of a Panasonic AG6850 VHS hi-fi duplicating recorder.

Video Mail Environment

The present invention is also adaptable to the storage, forwarding and distribution of video mail through conventional distribution media such as the Internet, CATV infrastructures, satellite or telephone lines. Video mail is a video message from a sender to a recipient which can be received, stored, and

retransmitted by the present invention. The video mail is received from a video capture facility 103 of Figure 1 or forwarded to the video capture facility 103 by a sender via known methods such as physical delivery of a media (tape, disk, etc.), or vie electronic communication services such as the Internet, cable television wiring, telephone connections, etc. The video mail is then stored at the manufacturing controller 107 until retrieved by the addresses upon demand, or forwarded automatically to a know destination.

When the video mail is retrieved, the distribution of the video files is as described above over the ATM switch 127 and the communication network 127. The ultimate destination depends upon the location of the ultimate addressee but can be via the Internet, through a retail outlet 20, a CATV headend2102, an RBOC 2103, a regional server 2101.

The present video mail or v-mail system uses a store and forward approach to receive, store and forward the v-mail. A retail location in Denver, for example will capture a v-mail message in retail location 20. The v-mail is uploaded to the host data server 10 where it is later downloaded to the location nearest to the intended recipient.

In the preferred embodiment, the full-motion video mail, or v-mail, will be captured at a retail outlet 20 for delivery to another retail outlet 20 in another location. The v-mail may be in full-motion, full format NTSC, PAL, SECAM, or other formats, or may be converted from one format (ie., NTSC) to the format required at the recipients location (ie., PAL). The recipient of the v-mail would be alerted to the receipt of a v-mail by telephone or other means. The recipient of the video mail may visit a retail outlet 20 to retrieve the video mail on a platform such as that found in kiosk 123. In the alternative, the v-mail may be written to a media such as video tape, disk or the like for later playback in the home.

In another embodiment, the v-mail may be recorded from or delivered to homes or offices equipped with a data capture or delivery system and a communication channel (such as CATV wiring) capable of the bandwidth to deliver the 10 megabytes per minute video data file. In order to minimize the

impact of the full-motion, full-screen video data file sizes on bandwidth limited communication channels, the video mail is captured at thirty frames per second in approximately 200 x 170 pixels. A standard PC with VGA graphics may be the platform for receiving the v-mail utilizing an MPEG-2 decoder card.

Digital Versatile Disk (DVD) Media

Digital Versatile Disk (DVD) is an anticipated replacement medium for VHS video tape for the distribution of prerecorded video. DVD disks can store up to 14 times more information than a typical CD-audio or CD-ROM (Read Only Memory) even though the DVD disk is the same size as the earlier CD-audio and CD-ROM disks.

The DVD disks obtain their higher data density due to a number of improvements over standard CD technology. Smaller DVD pits, and narrower data tracks provide a spiral which is twice the length of a CD-audio or CD-ROM disk. A writeable DVD disk uses photochemical techniques altered by a laser to simulate the reflective pits on a stamped manufactured DVD disk. Upon writing a DVD disk, chemicals in the substrate are changed by a laser to change their light-absorbing qualities, such that when a laser later reads a written DVD disk, the phase of the laser light is changed thereby mimicking the normal change in reflectivity on a pit within a factory-pressed DVD disk.

High Speed DVD Writer

Figure 23 shows a block diagram for the High Speed DVD writer of the present invention. When using the high speed DVD writer of Figure 23, there is no need to decompress the MPEG-2 data stream such that the high speed decompression engine is no longer needed. The data written to the DVD disk is written in the MPEG-2 format directly.

Conventional DVD writing machines operate using constant linear velocity (CLV) during the writing process. The present invention rotates the disk using Constant Angular Velocity (CAV) such that the disk does not change speed as the data is written to the disk. In this fashion, the write heads will be writing data at a faster rate toward the edge of the disk than in the interior of the disk.

As shown in Figure 23, the preferred embodiment of the high speed DVD writer 2300, four optical write heads 2301a-2301d are spaced at 90° locations around the DVD writeable disk 2302. Those skilled in the art will readily recognize that more than four heads may be used with the present invention. The optical DVD disk rotates at six time (6X) normal read speed under control of servo motor 2305 and servo controller 2304 and each optical write head 2302 writes data at six times the normal speed. With four optical write heads, the speed of recording a single layer on one side of a DVD disk becomes 24 times (24X) normal speed. By using CLV on the disk, the data flow to the heads necessarily speeds when up writing closer to the center of the disk on the data spiral of disk. A top view of the sector 2402 format of a typical DVD disk is shown in Figure 24 in which the sector formats are highlighted for clarity, but not in a spiral. As shown in Figure 24, more sectors of the DVD data track are written at the outer regions of the DVD disk 2302, than in the inner regions of the DVD disk.

In order to handle the differential data rates for the optical write heads 2301in CLV, data buffers within the record circuitry 2303 are utilized to store the prerecorded digital video data from the prerecorded video server via ATM switch 125. The buffers are addressed such that each write head 2301 writes a portion of the same contiguous data spiral simultaneously such that one quarter revolution of the DVD disk 2302 will write one complete rotation of data. The high speed DVD writer 2300 writes preformatted DVD writeable disks 2302 such that the DVD optical write heads follow the wobble groove or wobble track. This wobble track is a continuous spiral of a single track on DVD disk 2302. Each head 2301 writes from a beginning sector and address location to an ending sector and address location within the DVD disk 2302.

Since multiple write heads write contiguous portions of the same linear track to form concatenated portions of data, the Error Correction Codes (ECC) written as part of the DVD standard may experience discontinuities at the boundaries between the data portions written by each optical write head. This is because the ECC is continuous across the entire data stream using interleaving

and Hamming distance codes to correct for errors caused by scratches and misreads from the DVD. The advanced form of the Error Correction Codes used by the DVD standard are robust enough that the discontinuities caused by multiple head writes are not a problem upon playback. Those skilled in the art will recognize that an alternate embodiment would include precomputation of the Error Correction Codes for each head to eliminate discontinuities between sectors written by different heads.

Figure 25 is a side view of a multi-layer DVD recordable disk. Layers 2501 and 2502 represent recordable layers one and two, respectively. The opaque substrate 2503 is in the center with layers 2504 and 2505 representing recordable layers three and four, respectively. To record a multi-layer DVD recordable disk 2506, each head 2301 contains two fixed-focus lasers to record the data on each layer simultaneously. In a two sided DVD recordable disk 2506, four additional heads 2301e-2301h (latter heads not shown) are used to simultaneously record the top and bottom layers. In this fashion, a four layer, two-sided DVD recordable disk is recorded in ninety-six times (96X) the normal playback speed.

Those skilled in the art will readily recognize that the present high speed DVD writing machine of the present invention is capable of writing multiple media formats. Single-sided single-layer DVD, single-side multi-layer DVD, two-sided single layer DVD and two-sided multi-layer DVD are all within the scope of the present invention. DVD recordable disks having more than two layers per side is also envisioned by adding multiple fixed-focus lasers to each optical recording head 2301.

Those skilled in the art will also recognize that the present invention is also adaptable to writing multiple formats of data. MPEG-2 video data, music data, computer data and the like are all capable of being written in a high speed fashion. Thus, the retail outlet 20 described above may use high speed DVD writing devices to write prerecorded video for one customer, recordable DVD-Audio for another, recordable DVD-ROM computer disks for another, or recordable DVD-RAM for yet another customer. Since CD formats

are well developed in the art, it is also envisioned that the present invention is capable of writing the known formats for CD such as CD-Recordable Audio and CD-Recordable ROM.

CONCLUSION

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiments shown. This patent is intended to cover any adaptations or variations of the present invention. Therefore, it is manifestly intended that this invention be limited only by the claims and the equivalents thereof.

What is claimed is:

1. A high speed video recording apparatus for writing to a recordable digital versatile disk, comprising:

a plurality of optical write heads distributed at equidistant intervals over the surface of the recordable digital versatile disk;

a record circuit in communication with the plurality of optical write heads for distributing digital data to be written onto the recordable digital versatile disk; and

a disk servo control controlling a servo motor driving the recordable digital versatile disk at a constant liner velocity.

2. The high speed recording apparatus according to claim 1 wherein the record circuit includes a buffer memory space corresponding to each of the plurality of optical write heads to feed the digital data at a rate commensurate with the angular velocity of the recordable digital versatile disk.

3. The high speed recording apparatus according to claim 1 wherein the record circuit distributes the digital data to the plurality of optical write heads such that each of the plurality of optical write heads simultaneously records a separate segment of a contiguous portion of the digital data onto contiguous sectors of the recordable digital versatile disk.

4. The high speed recording apparatus according to claim 1 wherein the disk servo control circuit causes the recordable digital versatile disk to spin at more than the normal playback speed.

5. The high speed recording apparatus according to claim 4 wherein the disk servo control circuit causes the recordable digital versatile disk to spin at least six time the normal playback speed.

6. The high speed recording apparatus according to claim 1 wherein the digital data represents digitized prerecorded video.

7. The high speed recording apparatus according to claim 6 wherein the digitized prerecorded video is in MPEG-2 format.

8. The high speed recording apparatus according to claim 1 wherein the plurality of optical write heads are disposed on both the top and bottom surfaces of the recordable digital versatile disk.

9. The high speed recording apparatus according to claim 1 wherein the plurality of optical write heads include more than one laser, each focused for recording on a different layer of the recordable digital versatile disk.

10. A method of high speed recording of a recordable digital versatile disk, comprising the steps of:

receiving a plurality of streams of digital information, each stream representing a separate segment of a contiguous portion of the digital data;

sending each of the plurality of streams to a separate optical write head;

simultaneously writing each of the plurality streams of digital data onto a recordable digital versatile disk.

11. The method of high speed recording according to claim 10 wherein the step of receiving includes the step of receiving a plurality of streams of MPEG-2 digital information representing prerecorded video.

12. The method of high speed recording according to claim 11 wherein the step of sending includes the step dividing the MPEG-2 digital information into a number of segments such that the plurality of streams of digital information is recorded in a parallel fashion but is played back in a serial fashion.

13. A video distribution and manufacturing system, comprising:

a prerecorded video capture facility for capturing a prerecorded video content having a corresponding title and for producing therefrom digital data representing the prerecorded video content in the form of a prerecorded video data file;

a prerecorded video storage facility coupled to receive and store the prerecorded video data file;

a central host server coupled to the prerecorded video storage facility for cataloging the prerecorded video data file with the corresponding title and for retrieving the prerecorded video data file from the prerecorded video storage facility upon receipt of a transfer request;

a communications network coupled to the central host server for receiving the prerecorded video data file and for transmitting the prerecorded video data file over the communications network;

a remote server coupled to the communications network for receiving the prerecorded video data file;

a selection device coupled to the remote server for selecting the prerecorded video content for manufacture by the manufacturing device; and

a high speed digital versatile disk device coupled to the remote server and the selection device for recording the prerecorded video content from the prerecorded video data file onto a digital versatile disk at a speed faster then the normal playback speed.

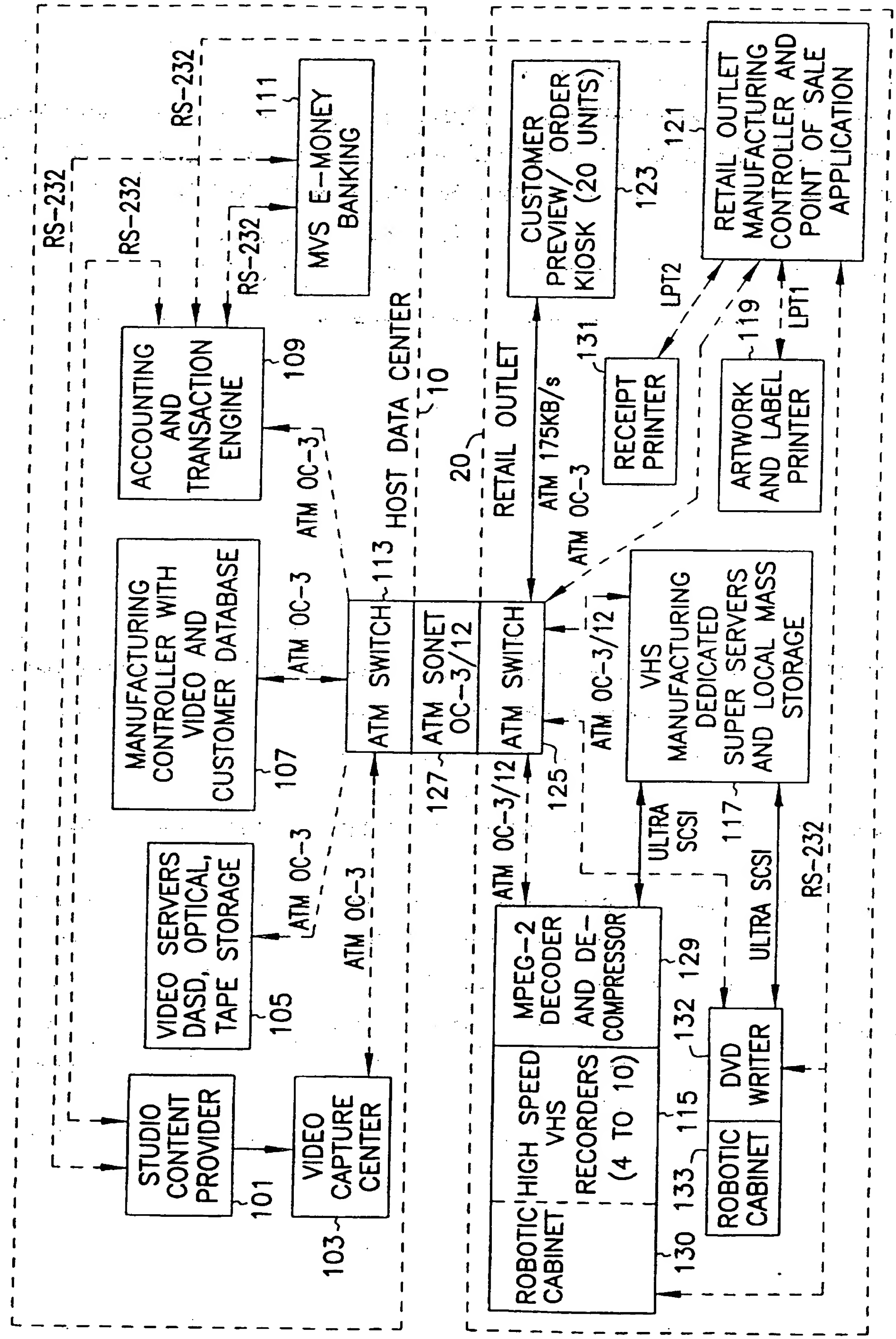
HOST DATA CENTER
10
STUDIO CONTENT PROVIDER
101
VIDEO CAPTURE CENTER
103
VIDEO SERVERS DASD, OPTICAL, TAPE STORAGE
105
MANUFACTURING CONTROLLER WITH VIDEO AND CUSTOMER DATABASE
107
ACCOUNTING AND TRANSACTION ENGINE
109
MVS E-MONEY BANKING
111
RS-232
RS-232
RS-232
RS-232
ATM OC-3
ATM OC-3
ATM OC-3
ATM OC-3
ATM SWITCH
113
ATM SONET OC-3/12
127
ATM SWITCH
125
RETAIL OUTLET
20
CUSTOMER PREVIEW/ ORDER KIOSK (20 UNITS)
123
RETAIL OUTLET MANUFACTURING CONTROLLER AND POINT OF SALE APPLICATION
121
LPT2
LPT1
RECEIPT PRINTER
131
ARTWORK AND LABEL PRINTER
119
ATM 175KB/s
ATM OC-3
ATM OC-3
ATM OC-3/12
ATM OC-3/12
ATM OC-3/12
VHS MANUFACTURING DEDICATED SUPER SERVERS AND LOCAL MASS STORAGE
117
ULTRA SCSI
ULTRA SCSI
RS-232
MPEG-2 DECODER AND DE-COMPRESSOR
129
HIGH SPEED VHS RECORDERS (4 TO 10)
115
ROBOTIC CABINET
130
DVD WRITER
132
ROBOTIC CABINET
133

FIG. 1

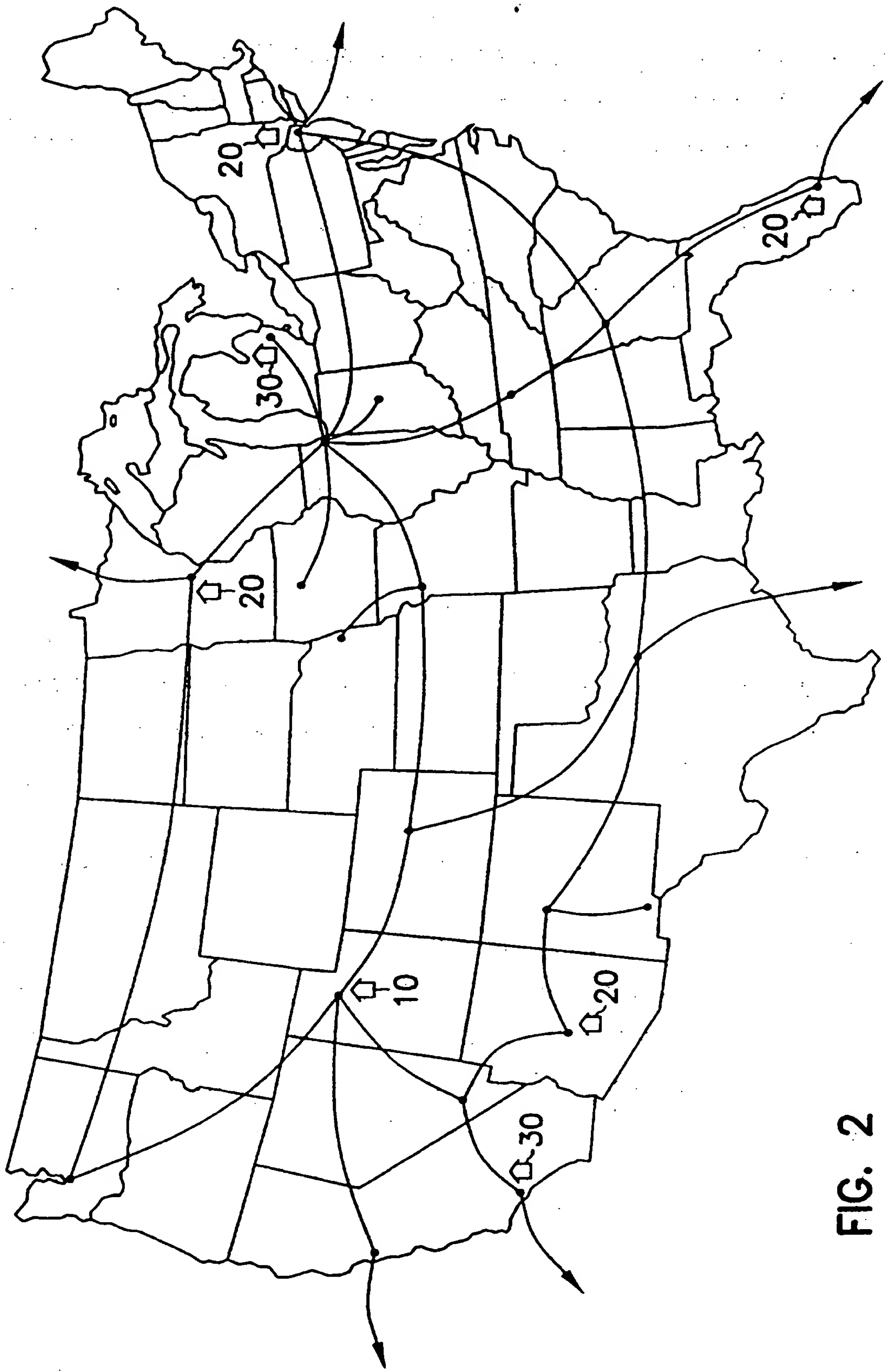

FIG. 2

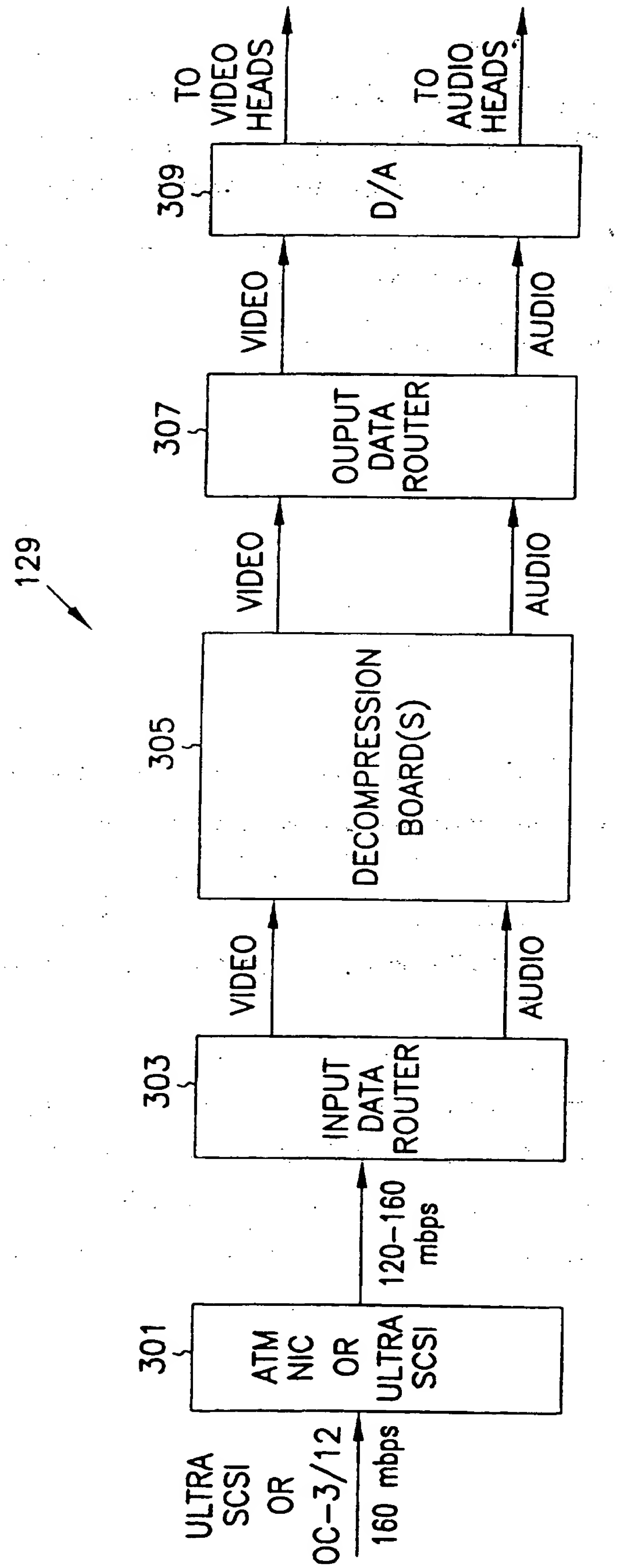
ULTRA SCSI OR OC–3/12
160 mbps
301
ATM NIC OR ULTRA SCSI
120–160 mbps
303
INPUT DATA ROUTER
VIDEO
AUDIO
305
DECOMPRESSION BOARD(S)
129
VIDEO
AUDIO
307
OUPUT DATA ROUTER
VIDEO
AUDIO
309
D/A
TO VIDEO HEADS
TO AUDIO HEADS

FIG. 3

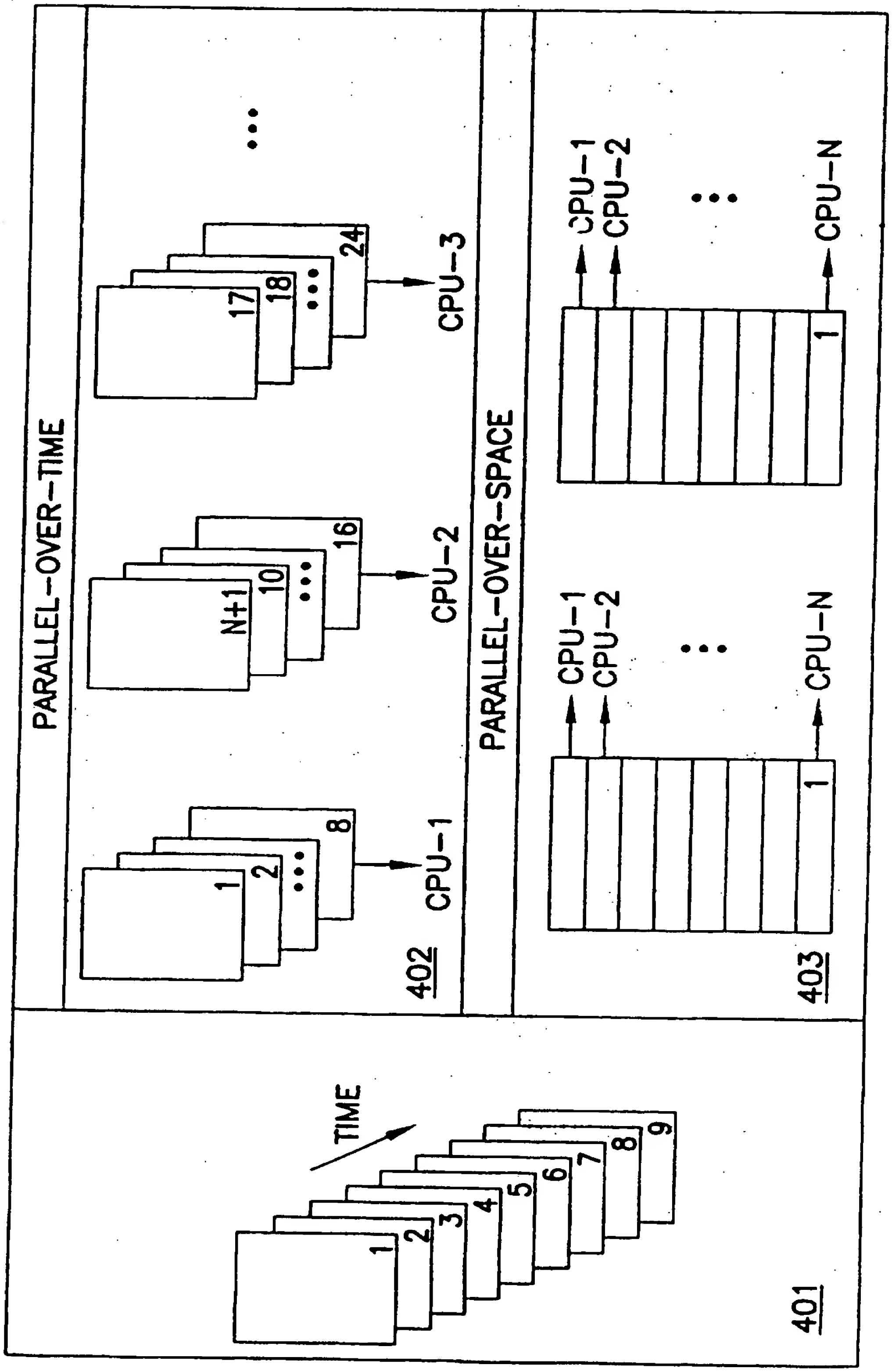
PARALLEL–OVER–TIME
1
2
8
CPU–1
N+1
10
16
CPU–2
17
18
24
CPU–3
402
PARALLEL–OVER–SPACE
CPU–1
CPU–2
CPU–N
1
403
TIME
1
2
3
4
5
6
7
8
9
401

FIG. 4

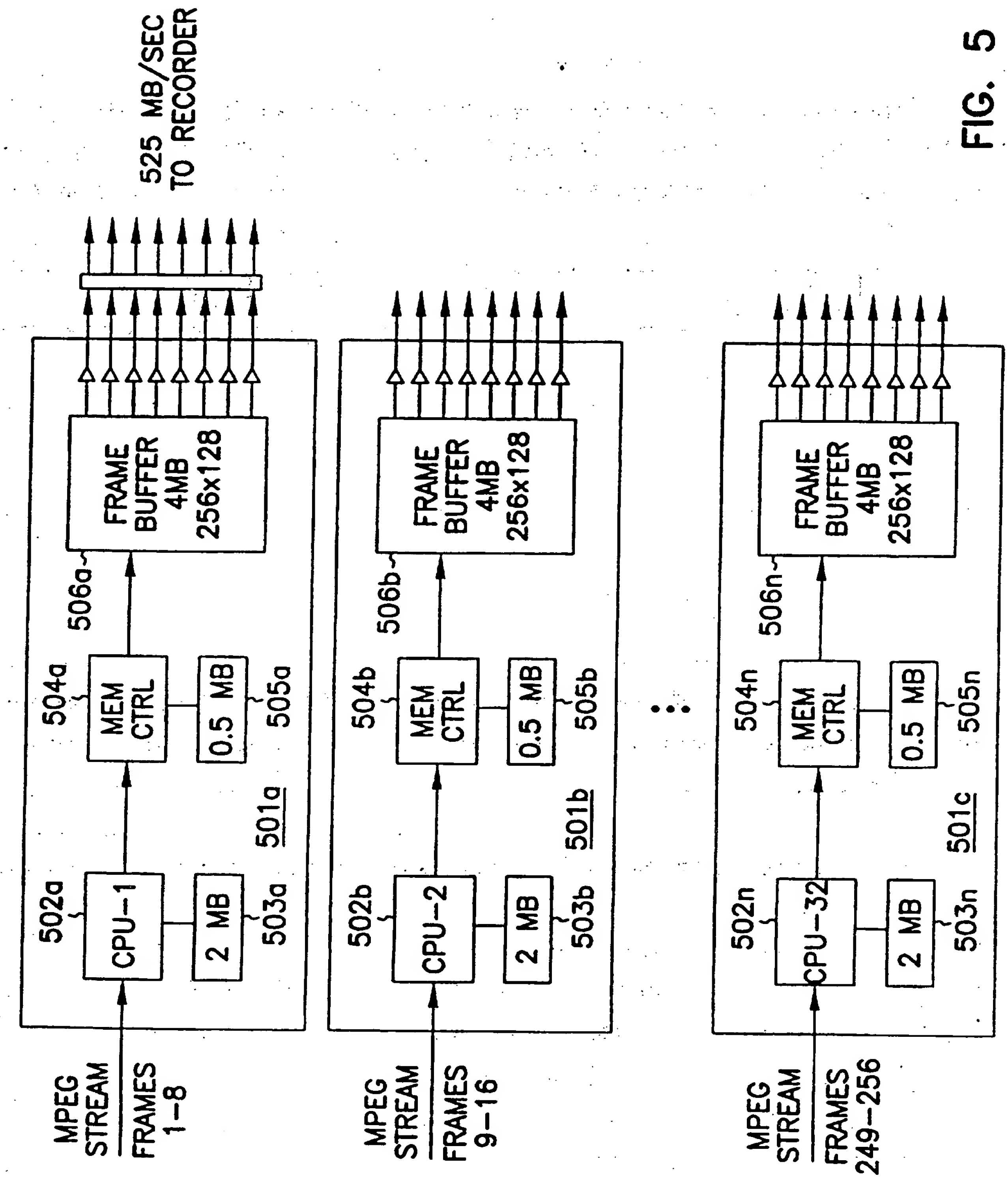
525 MB/SEC TO RECORDER
MPEG STREAM
FRAMES 1–8
502a
CPU–1
2 MB
503a
MEM CTRL
504a
0.5 MB
505a
501a
506a
FRAME BUFFER 4MB 256x128
MPEG STREAM
FRAMES 9–16
502b
CPU–2
2 MB
503b
MEM CTRL
504b
0.5 MB
505b
501b
506b
FRAME BUFFER 4MB 256x128
MPEG STREAM
FRAMES 249–256
502n
CPU–32
2 MB
503n
MEM CTRL
504n
0.5 MB
505n
501c
506n
FRAME BUFFER 4MB 256x128

FIG. 5

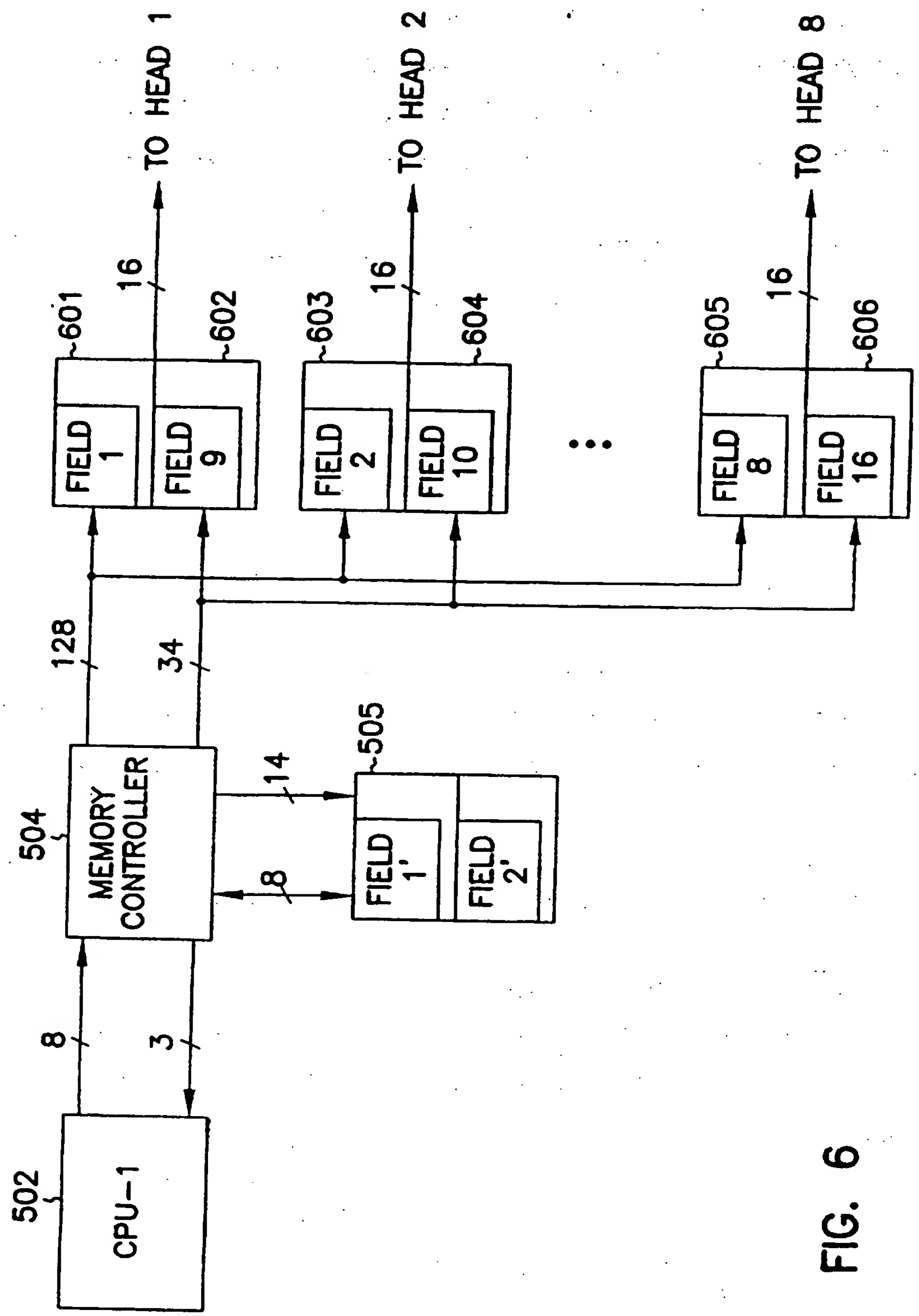
TO HEAD 1
TO HEAD 2
TO HEAD 8
16
16
16
601
602
603
604
605
606
FIELD 1
FIELD 9
FIELD 2
FIELD 10
FIELD 8
FIELD 16
128
34
505
14
8
FIELD 1'
FIELD 2'
504
MEMORY CONTROLLER
8
3
502
CPU-1

FIG. 6

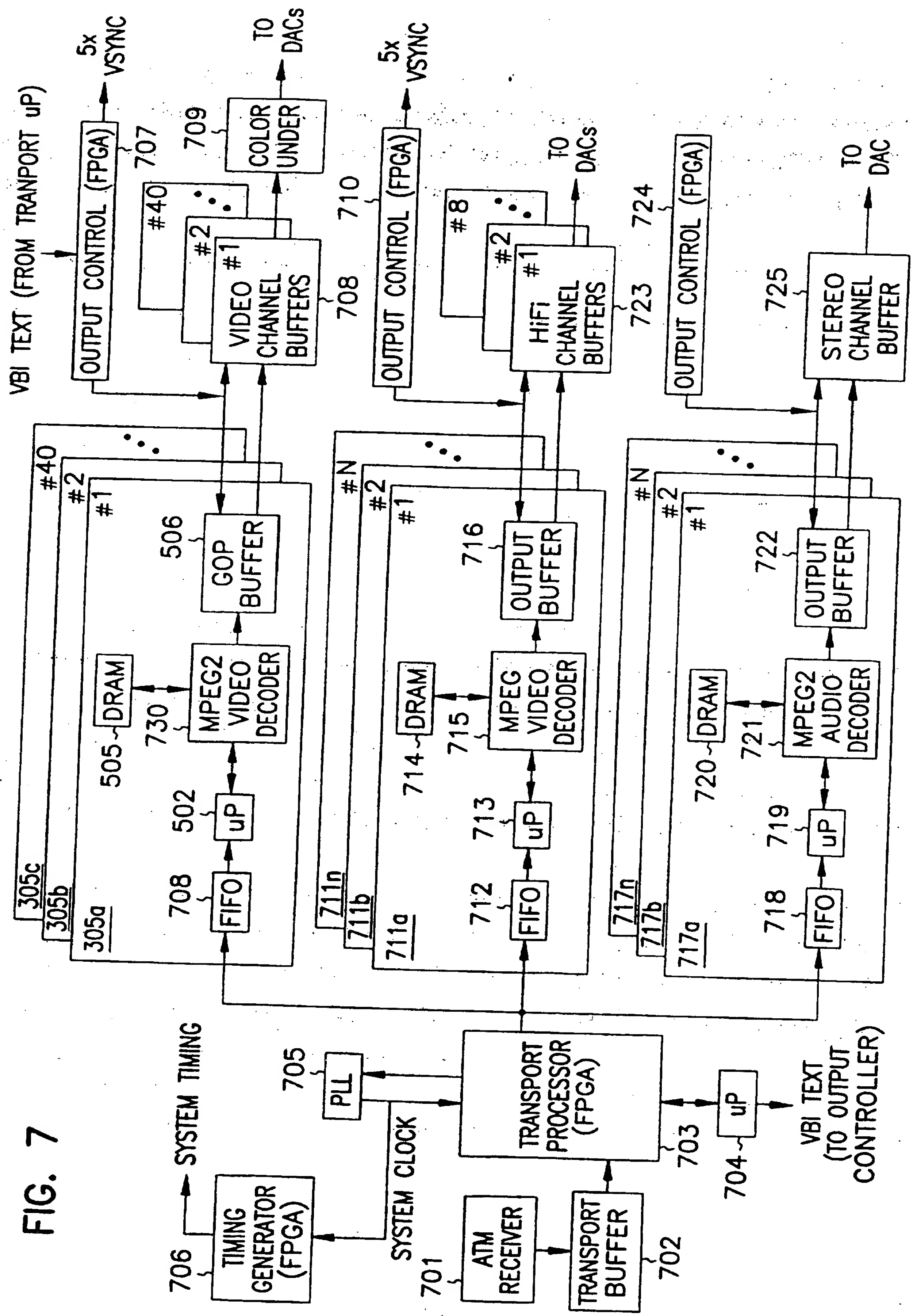
VBI TEXT (FROM TRANPORT uP)
OUTPUT CONTROL (FPGA)
707
5x VSYNC
VIDEO CHANNEL BUFFERS
#1
#2
#40
708
COLOR UNDER
709
TO DACs
305a
305b
305c
FIFO
708
uP
502
MPEG2 VIDEO DECODER
730
DRAM
505
GOP BUFFER
506
OUTPUT CONTROL (FPGA)
710
5x VSYNC
HiFi CHANNEL BUFFERS
#1
#2
#8
723
TO DACs
711a
711b
711n
#N
FIFO
712
uP
713
MPEG VIDEO DECODER
715
DRAM
714
OUTPUT BUFFER
716
OUTPUT CONTROL (FPGA)
724
STEREO CHANNEL BUFFER
725
TO DAC
717a
717b
717n
FIFO
718
uP
719
MPEG2 AUDIO DECODER
721
DRAM
720
OUTPUT BUFFER
722
SYSTEM TIMING
TIMING GENERATOR (FPGA)
706
SYSTEM CLOCK
PLL
705
TRANSPORT PROCESSOR (FPGA)
703
ATM RECEIVER
701
TRANSPORT BUFFER
702
uP
704
VBI TEXT (TO OUTPUT CONTROLLER)

FIG. 7

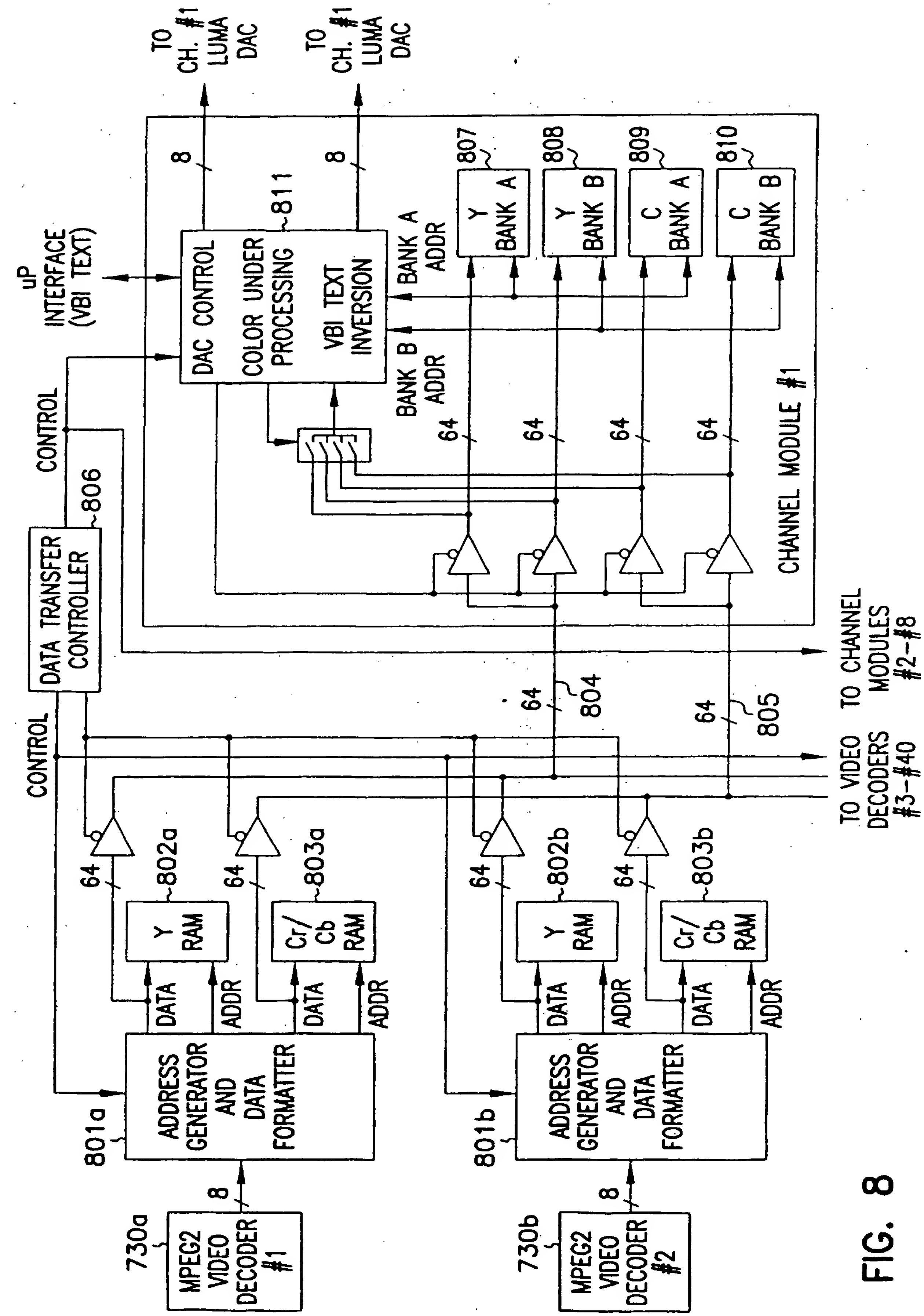
TO CH. #1 LUMA DAC
TO CH. #1 LUMA DAC
8
8
uP INTERFACE (VBI TEXT)
DAC CONTROL
COLOR UNDER PROCESSING
VBI TEXT INVERSION
811
BANK A ADDR
BANK B ADDR
807
808
809
810
Y BANK A
Y BANK B
C BANK A
C BANK B
CONTROL
DATA TRANSFER CONTROLLER
806
64
CHANNEL MODULE #1
TO CHANNEL MODULES #2-#8
804
805
CONTROL
TO VIDEO DECODERS #3-#40
802a
803a
802b
803b
Y RAM
Cr/Cb RAM
DATA
ADDR
801a
801b
ADDRESS GENERATOR AND DATA FORMATTER
730a
730b
MPEG2 VIDEO DECODER #1
MPEG2 VIDEO DECODER #2

FIG. 8

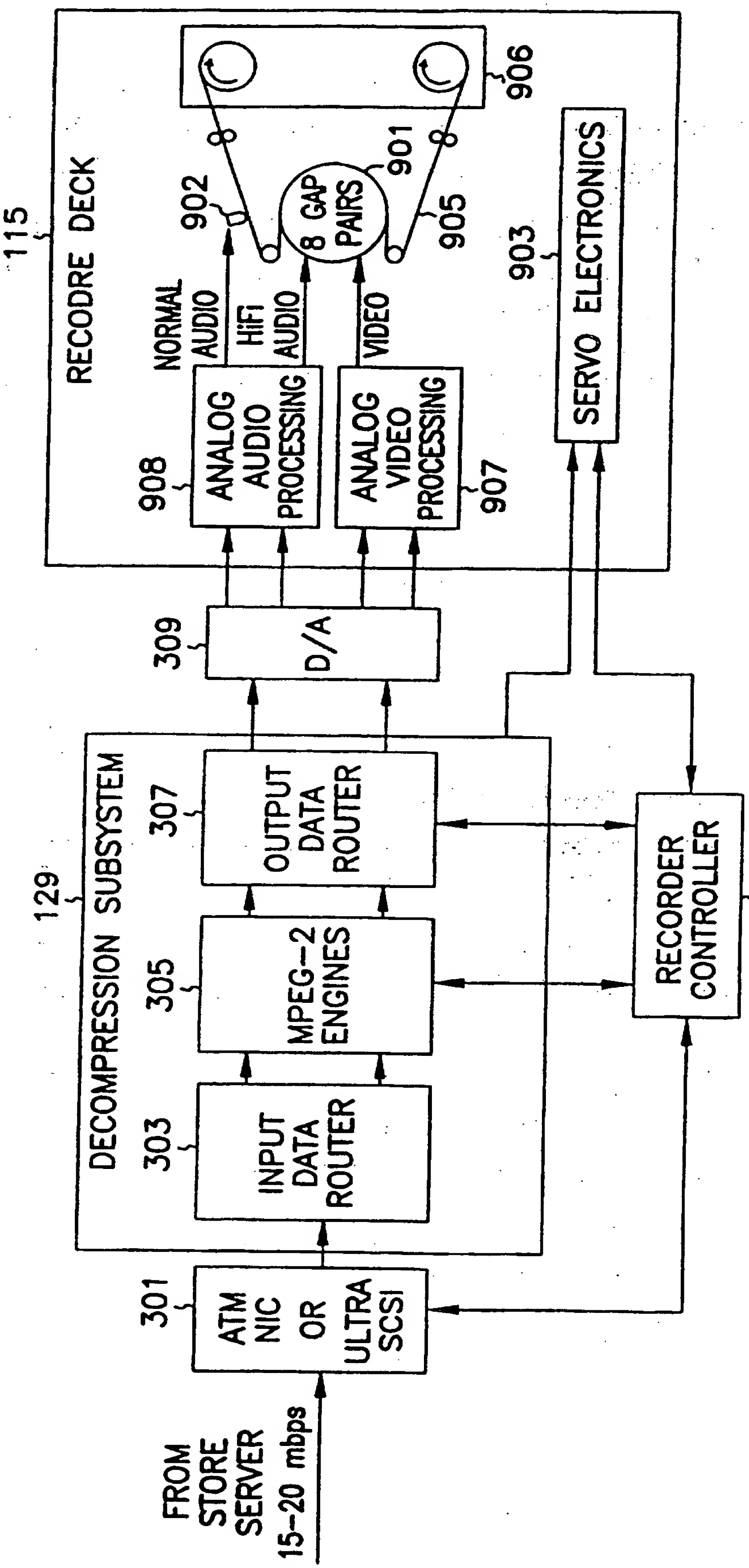
FROM STORE SERVER 15–20 mbps
ATM NIC OR ULTRA SCSI
301
DECOMPRESSION SUBSYSTEM
129
INPUT DATA ROUTER
303
MPEG–2 ENGINES
305
OUTPUT DATA ROUTER
307
D/A
309
RECORDER CONTROLLER
904
RECODRE DECK
115
ANALOG AUDIO PROCESSING
908
ANALOG VIDEO PROCESSING
907
NORMAL AUDIO
HiFi AUDIO
VIDEO
8 GAP PAIRS
901
902
905
906
SERVO ELECTRONICS
903

FIG. 9

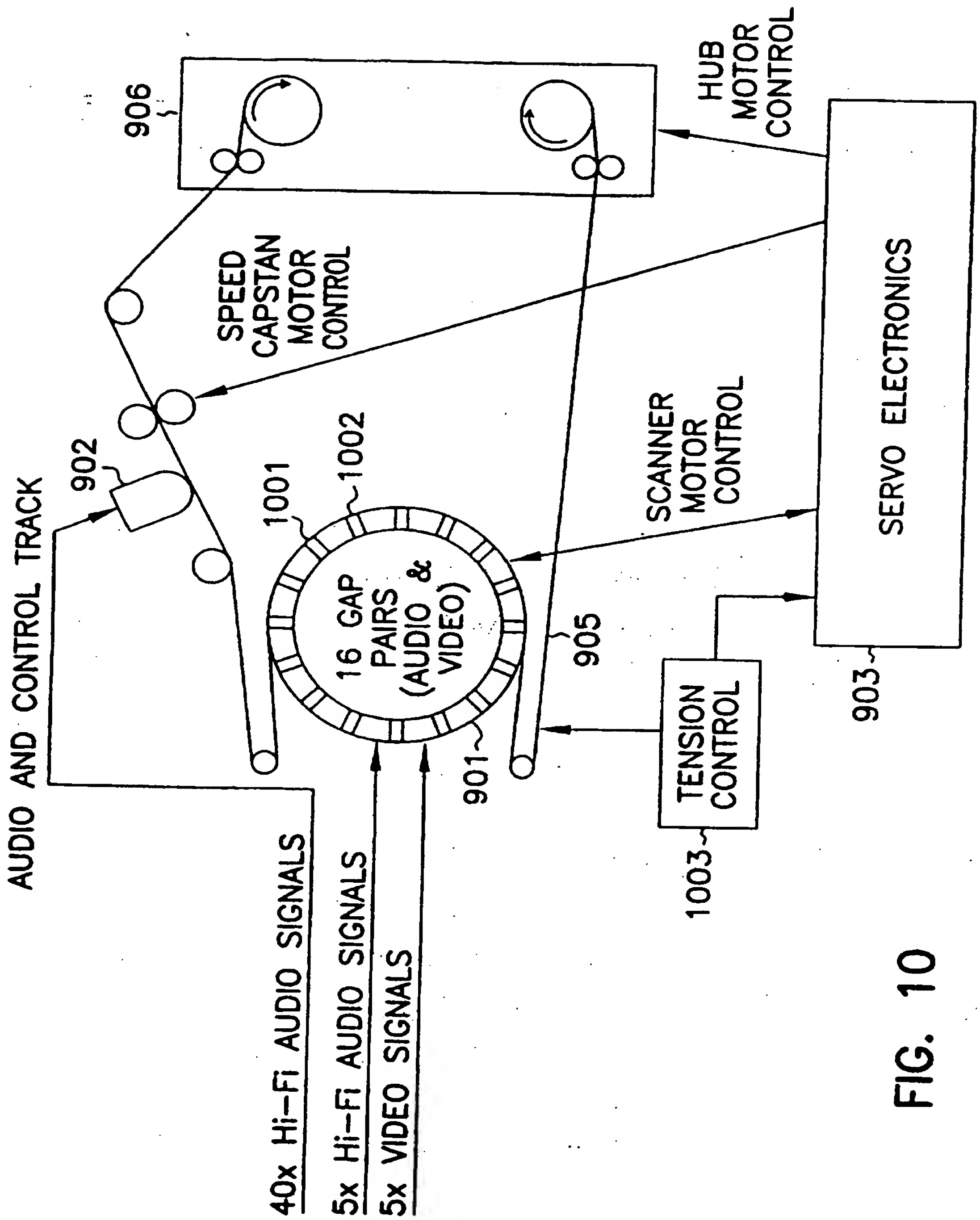
906
HUB MOTOR CONTROL
SPEED CAPSTAN MOTOR CONTROL
SERVO ELECTRONICS
902
AUDIO AND CONTROL TRACK
1001
1002
16 GAP PAIRS (AUDIO & VIDEO)
SCANNER MOTOR CONTROL
905
903
901
TENSION CONTROL
1003
40x Hi-Fi AUDIO SIGNALS
5x Hi-Fi AUDIO SIGNALS
5x VIDEO SIGNALS

FIG. 10

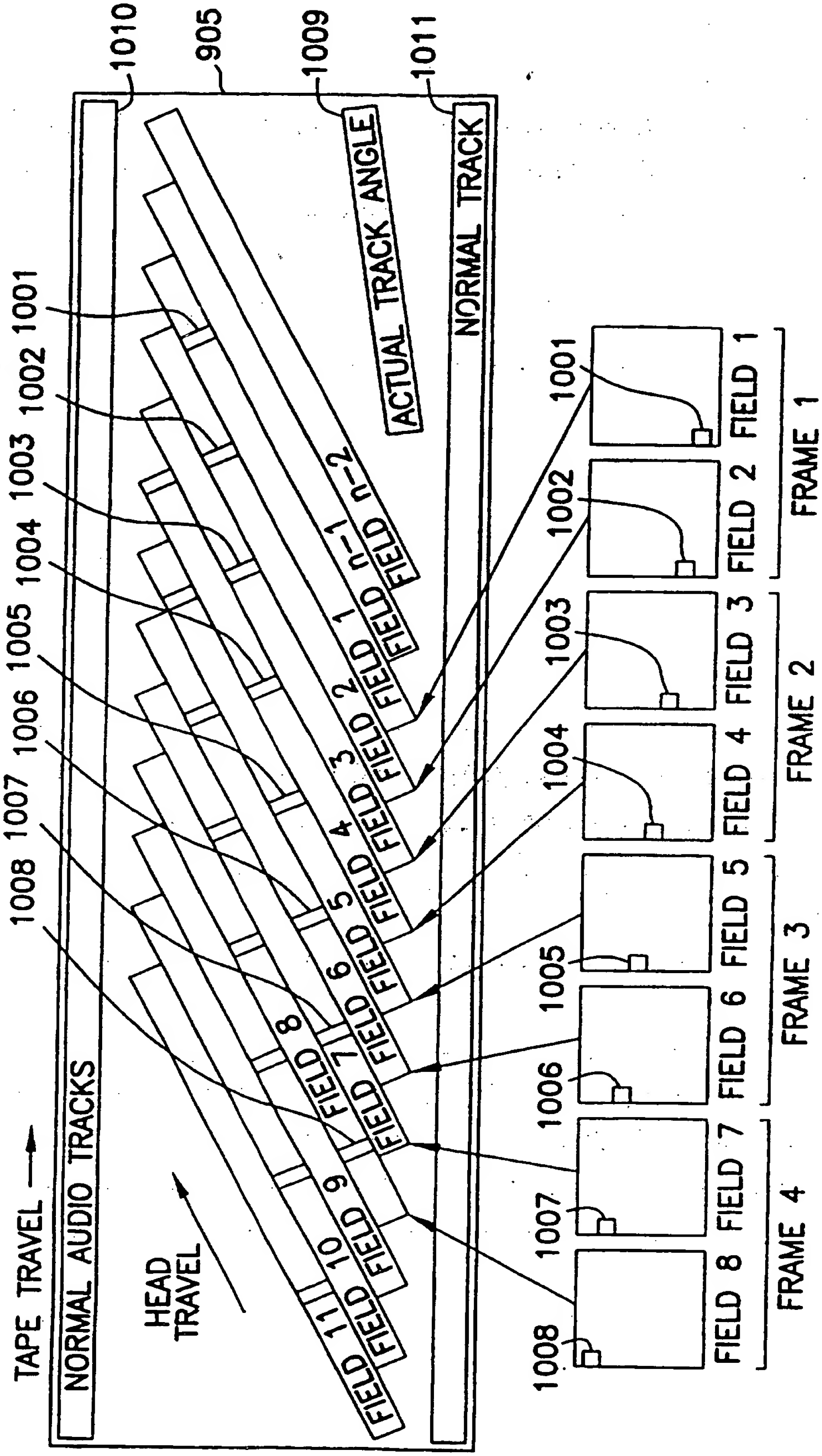
1010
905
1009
1011
ACTUAL TRACK ANGLE
NORMAL TRACK
NORMAL AUDIO TRACKS
TAPE TRAVEL
HEAD TRAVEL
FIELD n-2
FIELD n-1
FIELD 1
FIELD 2
FIELD 3
FIELD 4
FIELD 5
FIELD 6
FIELD 7
FIELD 8
FIELD 9
FIELD 10
FIELD 11
1001
1002
1003
1004
1005
1006
1007
1008
FRAME 1
FRAME 2
FRAME 3
FRAME 4

FIG. 11

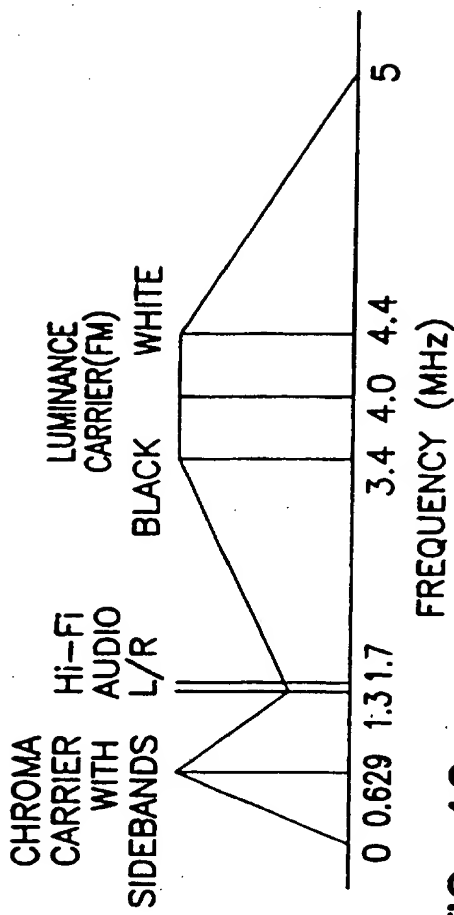
CHROMA CARRIER WITH SIDEBANDS
Hi-Fi AUDIO L/R
LUMINANCE CARRIER(FM)
BLACK
WHITE
0 0.629 1.3 1.7
3.4 4.0 4.4
5
FREQUENCY (MHz)

FIG. 12

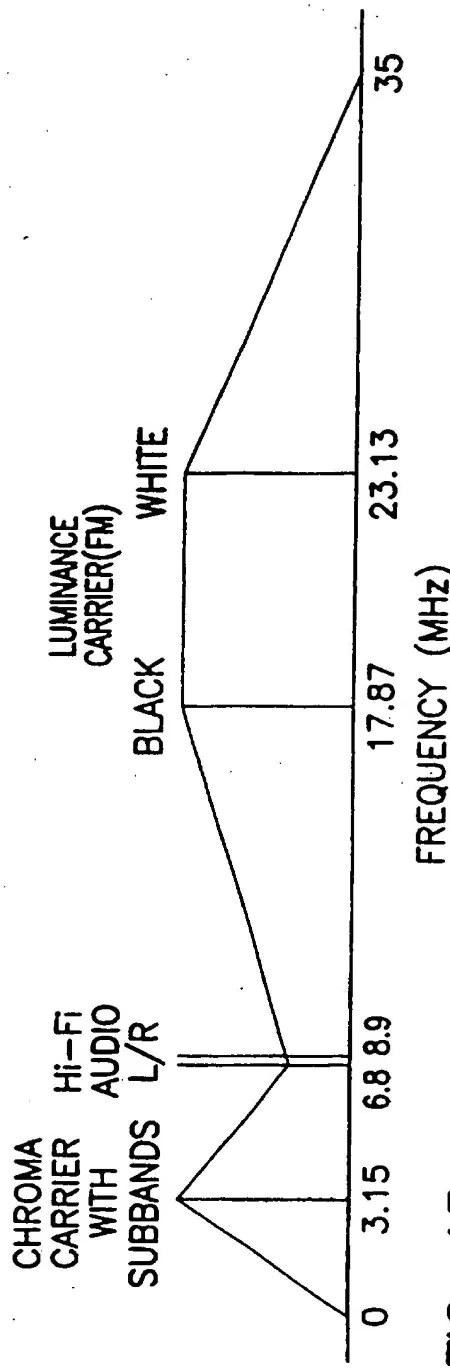
CHROMA CARRIER WITH SUBBANDS
Hi-Fi AUDIO L/R
LUMINANCE CARRIER(FM)
BLACK
WHITE
0
3.15
6.8 8.9
17.87
23.13
35
FREQUENCY (MHz)

FIG. 13

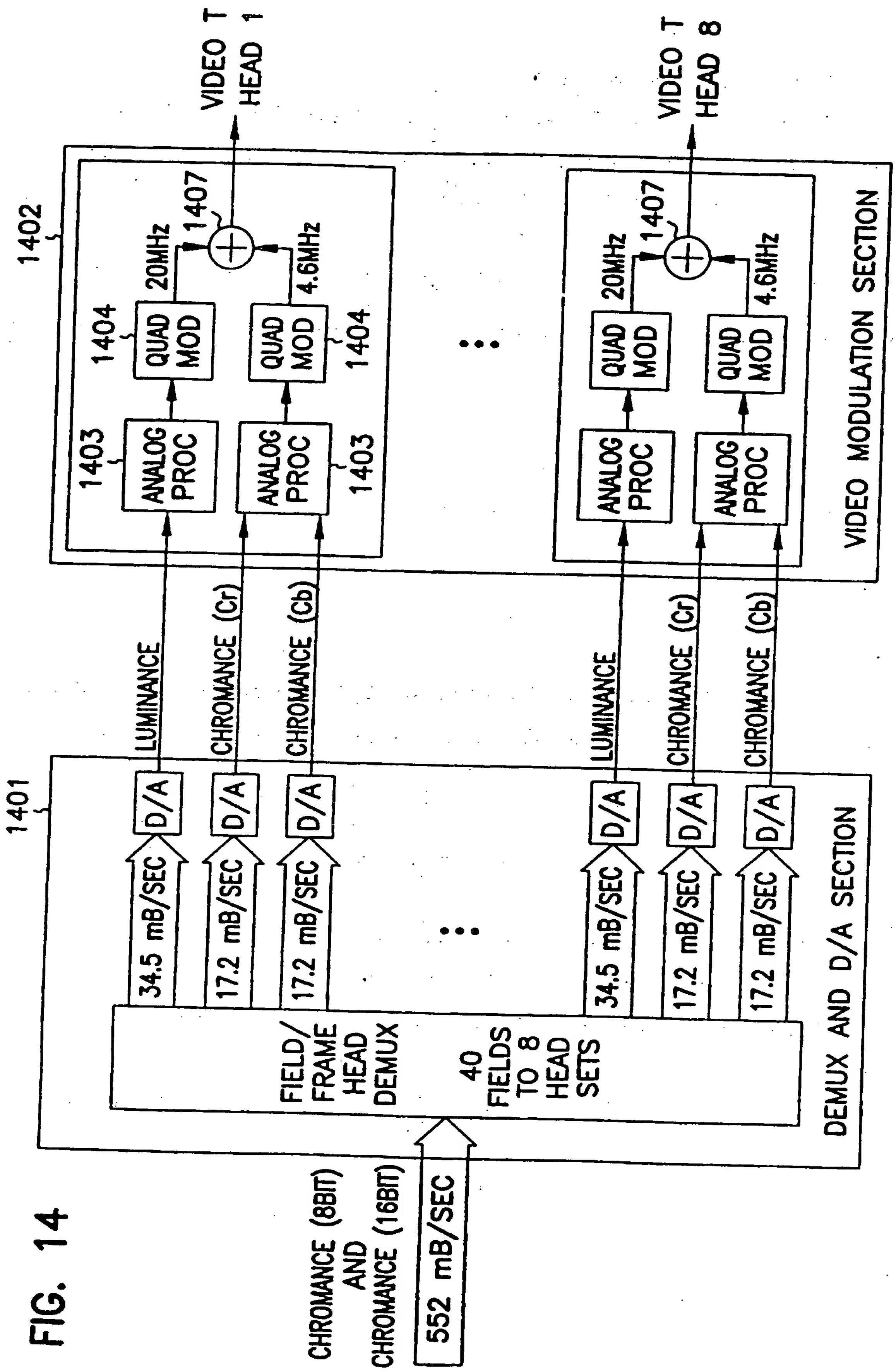
VIDEO T HEAD 1
VIDEO T HEAD 8
1402
1407
20MHz
4.6MHz
1404
QUAD MOD
1403
ANALOG PROC
VIDEO MODULATION SECTION
LUMINANCE
CHROMANCE (Cr)
CHROMANCE (Cb)
1401
D/A
34.5 mB/SEC
17.2 mB/SEC
FIELD/ FRAME HEAD DEMUX
40 FIELDS TO 8 HEAD SETS
DEMUX AND D/A SECTION
CHROMANCE (8BIT) AND CHROMANCE (16BIT)
552 mB/SEC

FIG. 14

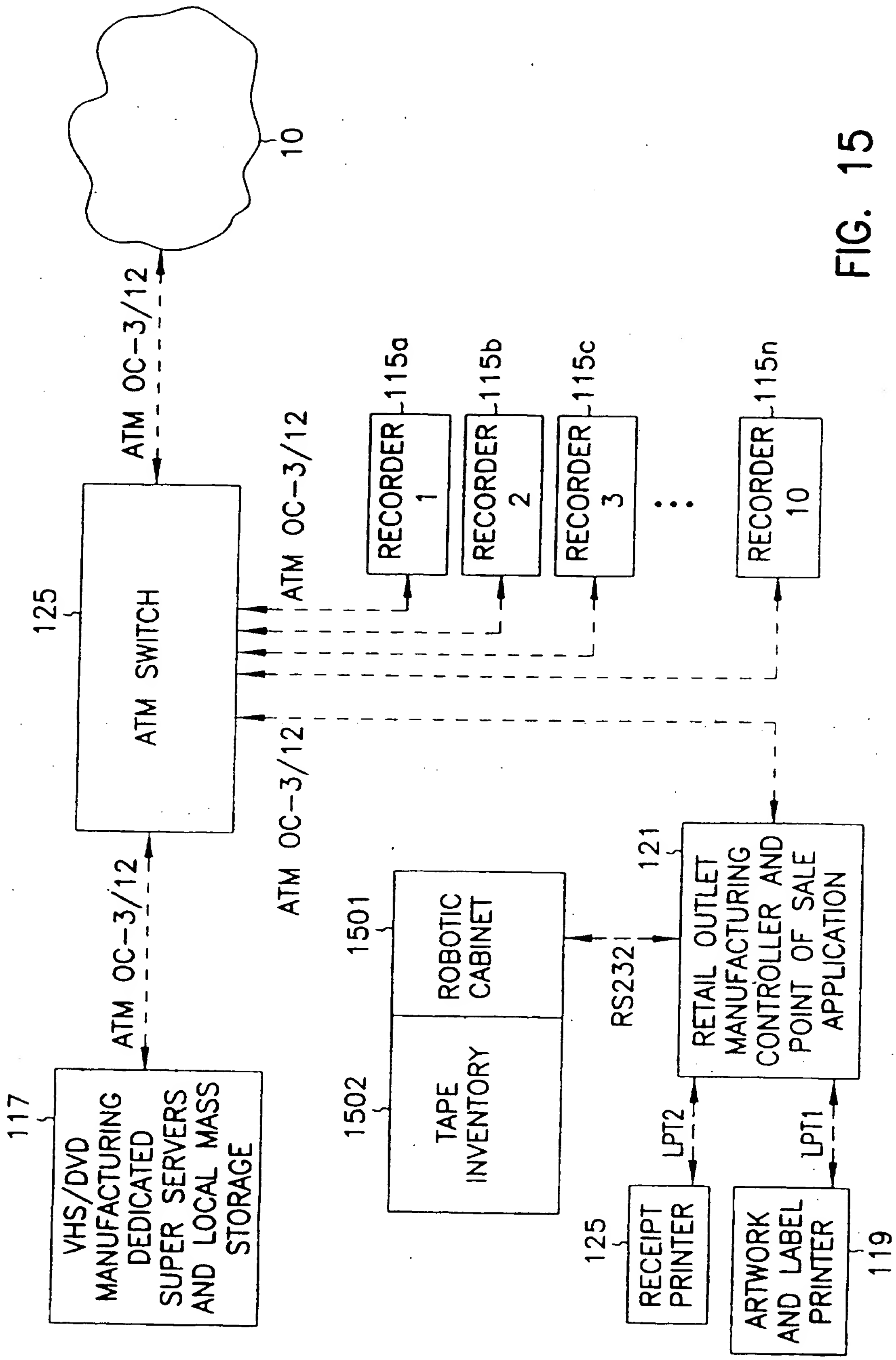
10
ATM OC-3/12
125
ATM SWITCH
ATM OC-3/12
RECORDER 1
115a
RECORDER 2
115b
RECORDER 3
115c
RECORDER 10
115n
ATM OC-3/12
ATM OC-3/12
117
VHS/DVD MANUFACTURING DEDICATED SUPER SERVERS AND LOCAL MASS STORAGE
1501
ROBOTIC CABINET
1502
TAPE INVENTORY
RS232
121
RETAIL OUTLET MANUFACTURING CONTROLLER AND POINT OF SALE APPLICATION
LPT2
LPT1
125
RECEIPT PRINTER
ARTWORK AND LABEL PRINTER
119

FIG. 15

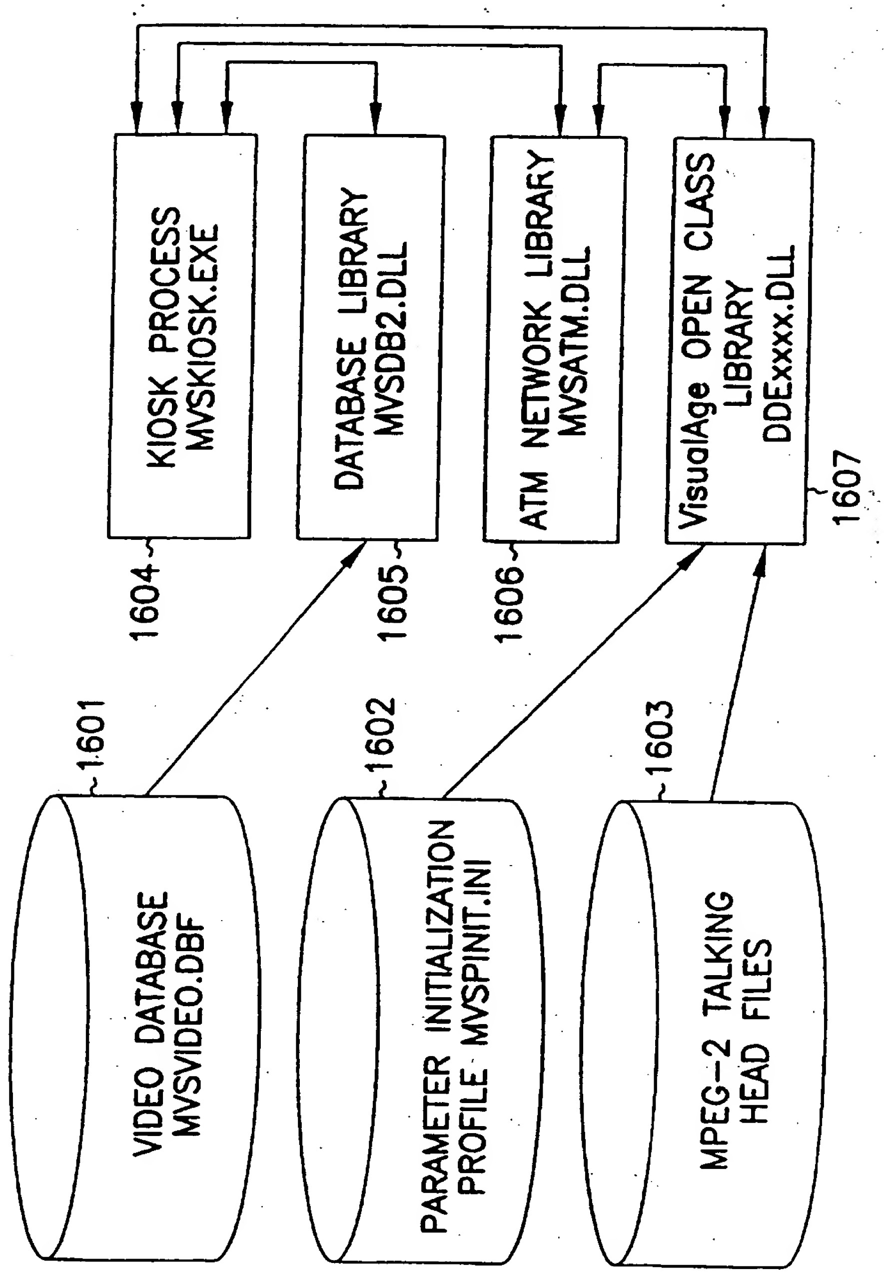
KIOSK PROCESS
MVSKIOSK.EXE
1604
DATABASE LIBRARY
MVSDB2.DLL
1605
ATM NETWORK LIBRARY
MVSATM.DLL
1606
VisualAge OPEN CLASS
LIBRARY
DDExxxx.DLL
1607
VIDEO DATABASE
MVSVIDEO.DBF
1601
PARAMETER INITIALIZATION
PROFILE MVSPINIT.INI
1602
MPEG-2 TALKING
HEAD FILES
1603

FIG. 16

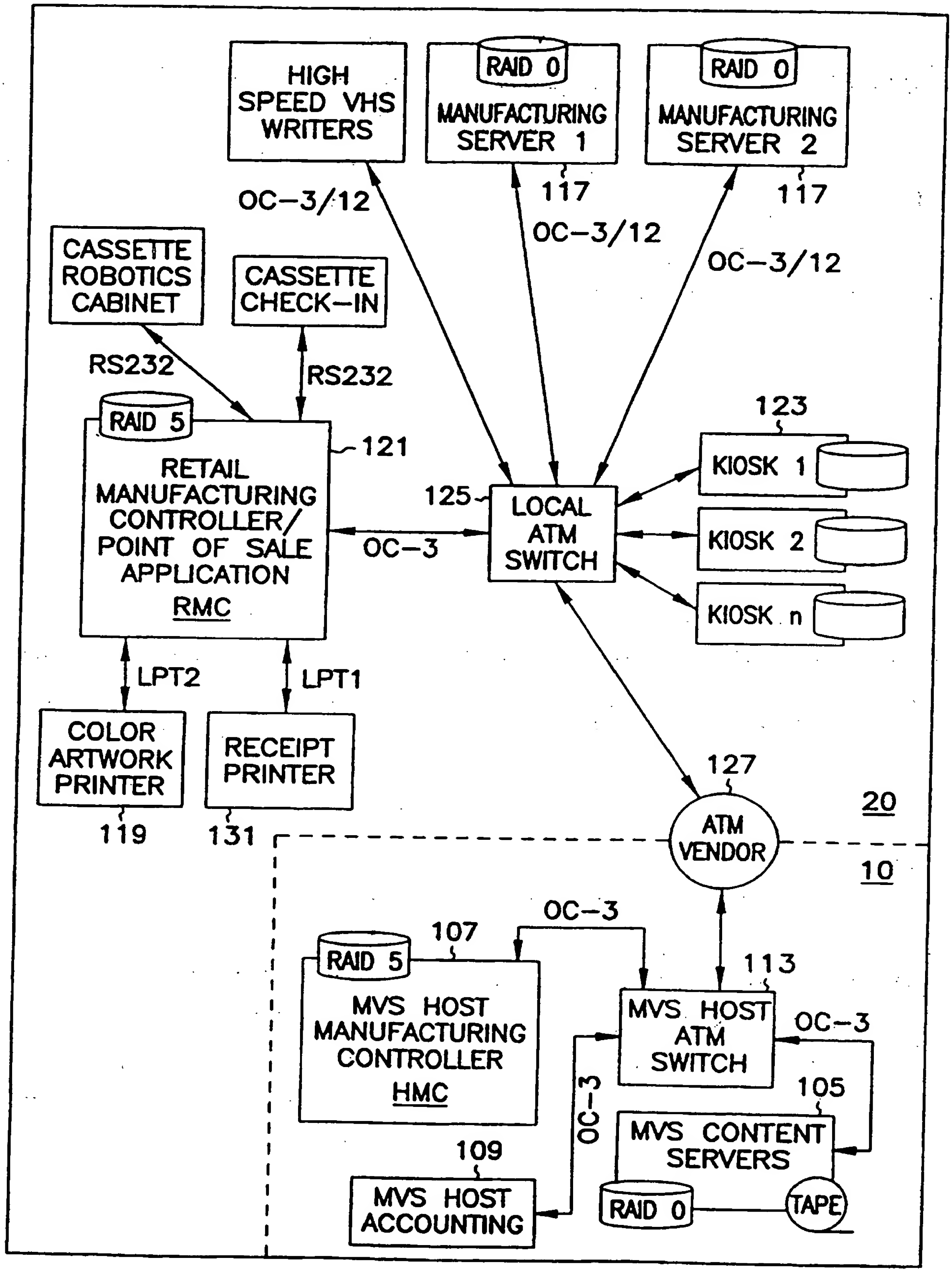
HIGH SPEED VHS WRITERS
RAID 0
MANUFACTURING SERVER 1
RAID 0
MANUFACTURING SERVER 2
117
117
OC-3/12
OC-3/12
OC-3/12
CASSETTE ROBOTICS CABINET
CASSETTE CHECK-IN
RS232
RS232
123
RAID 5
121
RETAIL MANUFACTURING CONTROLLER/ POINT OF SALE APPLICATION
RMC
125
LOCAL ATM SWITCH
OC-3
KIOSK 1
KIOSK 2
KIOSK n
LPT2
LPT1
COLOR ARTWORK PRINTER
RECEIPT PRINTER
119
131
127
ATM VENDOR
20
10
OC-3
107
RAID 5
MVS HOST MANUFACTURING CONTROLLER
HMC
113
MVS HOST ATM SWITCH
OC-3
OC-3
105
MVS CONTENT SERVERS
109
MVS HOST ACCOUNTING
RAID 0
TAPE

FIG. 17

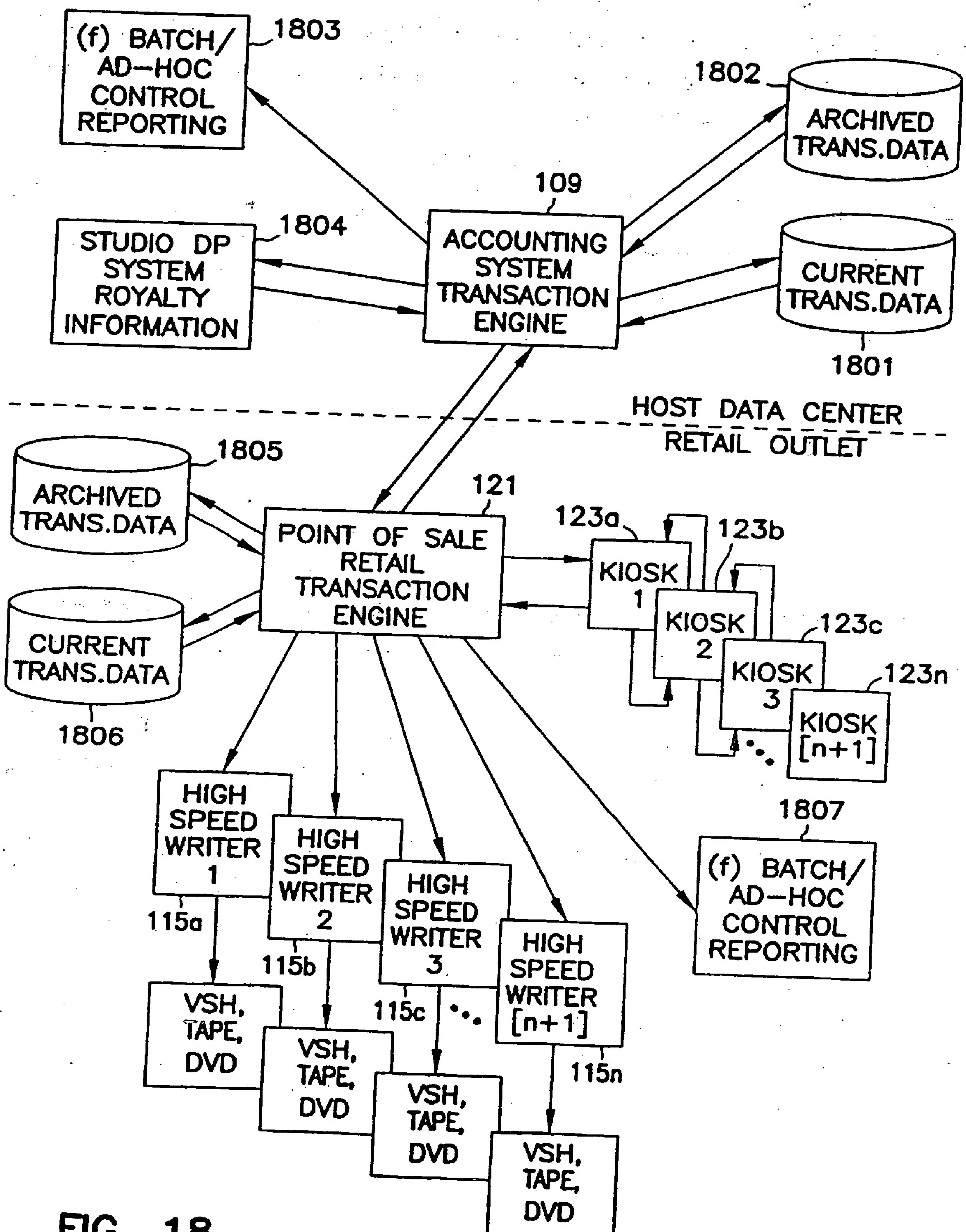
(f) BATCH/ AD-HOC CONTROL REPORTING
1803
1802
ARCHIVED TRANS.DATA
109
STUDIO DP SYSTEM ROYALTY INFORMATION
1804
ACCOUNTING SYSTEM TRANSACTION ENGINE
CURRENT TRANS.DATA
1801
HOST DATA CENTER
RETAIL OUTLET
ARCHIVED TRANS.DATA
1805
121
123a
123b
POINT OF SALE RETAIL TRANSACTION ENGINE
KIOSK 1
KIOSK 2
123c
KIOSK 3
123n
CURRENT TRANS.DATA
1806
KIOSK [n+1]
HIGH SPEED WRITER 1
HIGH SPEED WRITER 2
HIGH SPEED WRITER 3
HIGH SPEED WRITER [n+1]
1807
(f) BATCH/ AD-HOC CONTROL REPORTING
115a
115b
115c
115n
VSH, TAPE, DVD
VSH, TAPE, DVD
VSH, TAPE, DVD
VSH, TAPE, DVD

FIG. 18

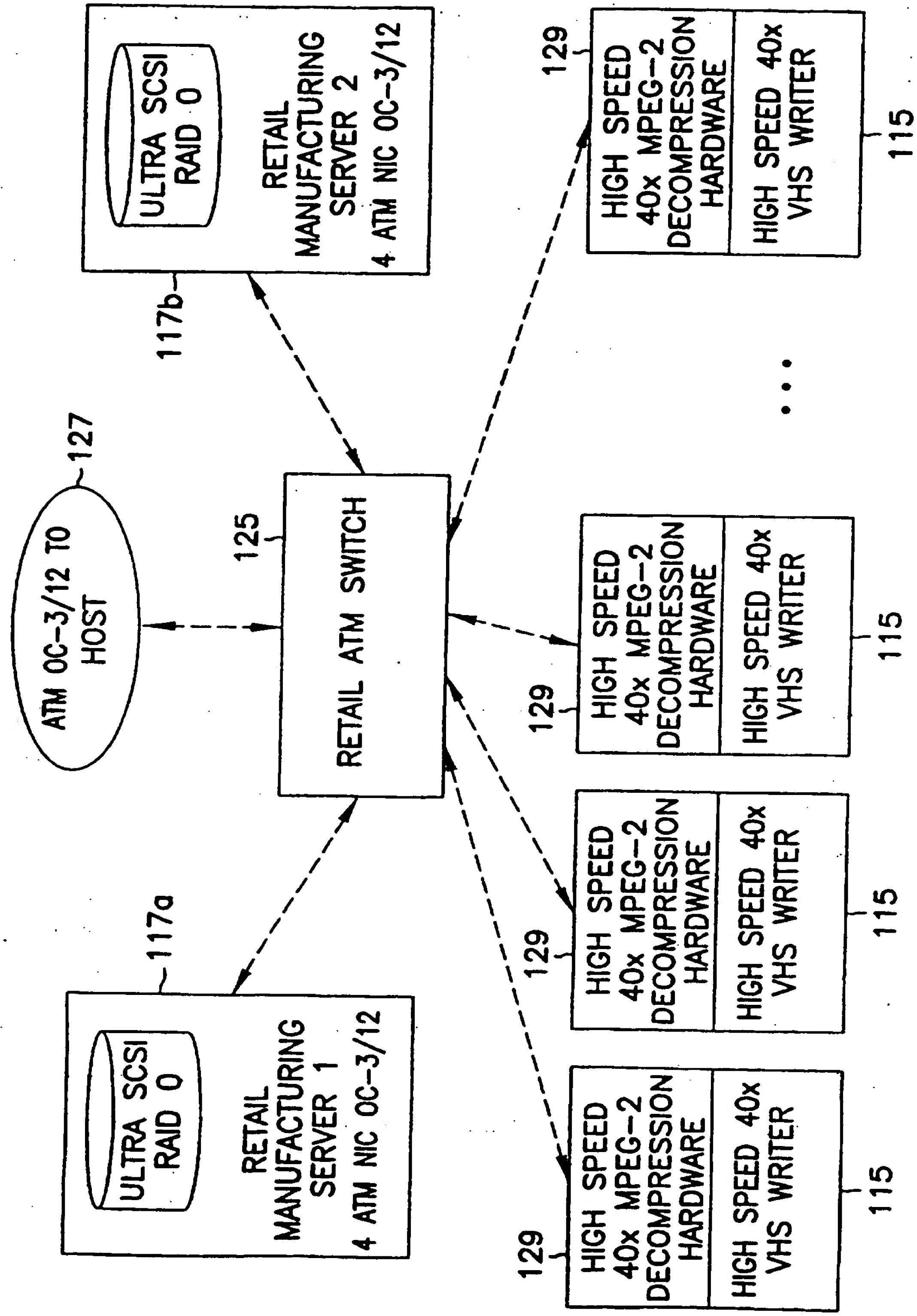
ATM OC-3/12 TO HOST
127
RETAIL ATM SWITCH
125
ULTRA SCSI RAID 0
RETAIL MANUFACTURING SERVER 2
4 ATM NIC OC-3/12
117b
ULTRA SCSI RAID 0
RETAIL MANUFACTURING SERVER 1
4 ATM NIC OC-3/12
117a
HIGH SPEED 40x MPEG-2 DECOMPRESSION HARDWARE
129
HIGH SPEED 40x VHS WRITER
115
HIGH SPEED 40x MPEG-2 DECOMPRESSION HARDWARE
129
HIGH SPEED 40x VHS WRITER
115
HIGH SPEED 40x MPEG-2 DECOMPRESSION HARDWARE
129
HIGH SPEED 40x VHS WRITER
115
HIGH SPEED 40x MPEG-2 DECOMPRESSION HARDWARE
129
HIGH SPEED 40x VHS WRITER
115

FIG. 19

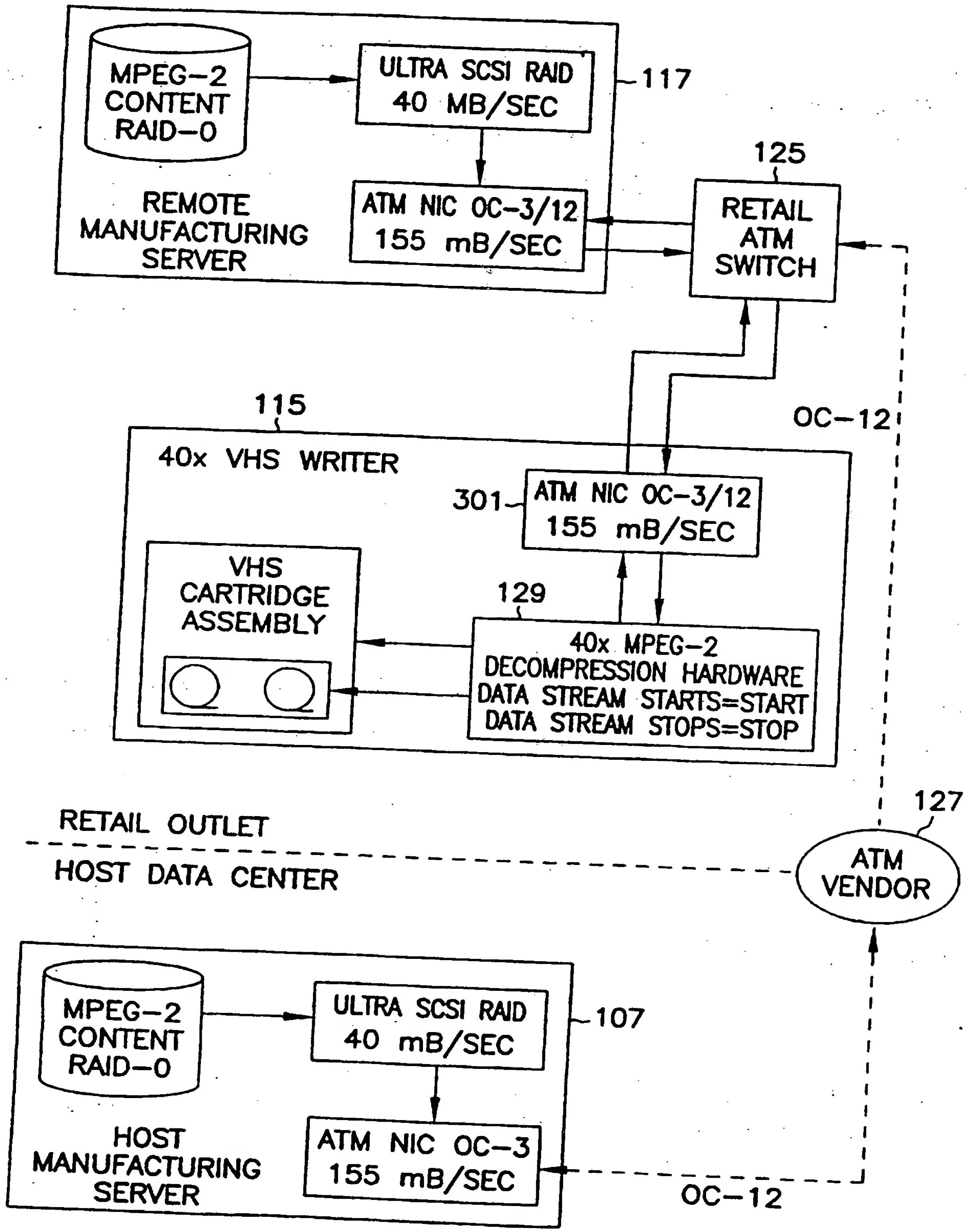
MPEG-2
CONTENT
RAID-0
ULTRA SCSI RAID
40 MB/SEC
117
125
ATM NIC OC-3/12
155 mB/SEC
REMOTE
MANUFACTURING
SERVER
RETAIL
ATM
SWITCH
115
OC-12
40x VHS WRITER
301
ATM NIC OC-3/12
155 mB/SEC
VHS
CARTRIDGE
ASSEMBLY
129
40x MPEG-2
DECOMPRESSION HARDWARE
DATA STREAM STARTS=START
DATA STREAM STOPS=STOP
RETAIL OUTLET
127
HOST DATA CENTER
ATM
VENDOR
MPEG-2
CONTENT
RAID-0
ULTRA SCSI RAID
40 mB/SEC
107
HOST
MANUFACTURING
SERVER
ATM NIC OC-3
155 mB/SEC
OC-12

FIG. 20

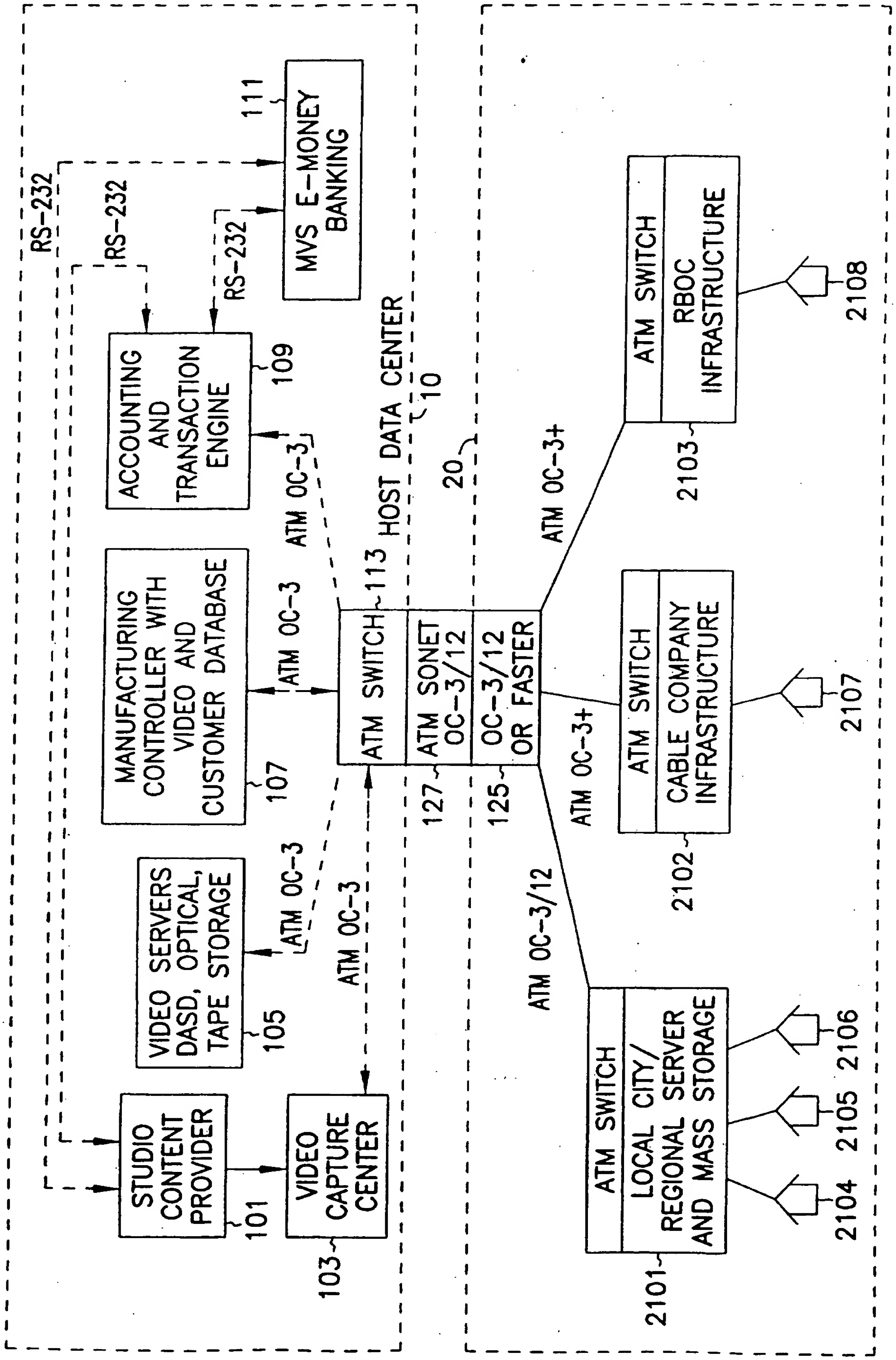
MVS E-MONEY BANKING
111
RS-232
RS-232
RS-232
ACCOUNTING AND TRANSACTION ENGINE
109
HOST DATA CENTER
10
20
MANUFACTURING CONTROLLER WITH VIDEO AND CUSTOMER DATABASE
107
ATM OC-3
ATM OC-3
ATM SWITCH
113
ATM SONET OC-3/12
127
OC-3/12 OR FASTER
125
VIDEO SERVERS DASD, OPTICAL, TAPE STORAGE
105
ATM OC-3
ATM OC-3
ATM OC-3
STUDIO CONTENT PROVIDER
101
VIDEO CAPTURE CENTER
103
ATM OC-3+
ATM OC-3+
ATM OC-3/12
ATM SWITCH
RBOC INFRASTRUCTURE
2103
2108
ATM SWITCH
CABLE COMPANY INFRASTRUCTURE
2102
2107
ATM SWITCH
LOCAL CITY/ REGIONAL SERVER AND MASS STORAGE
2101
2104
2105
2106

FIG. 21

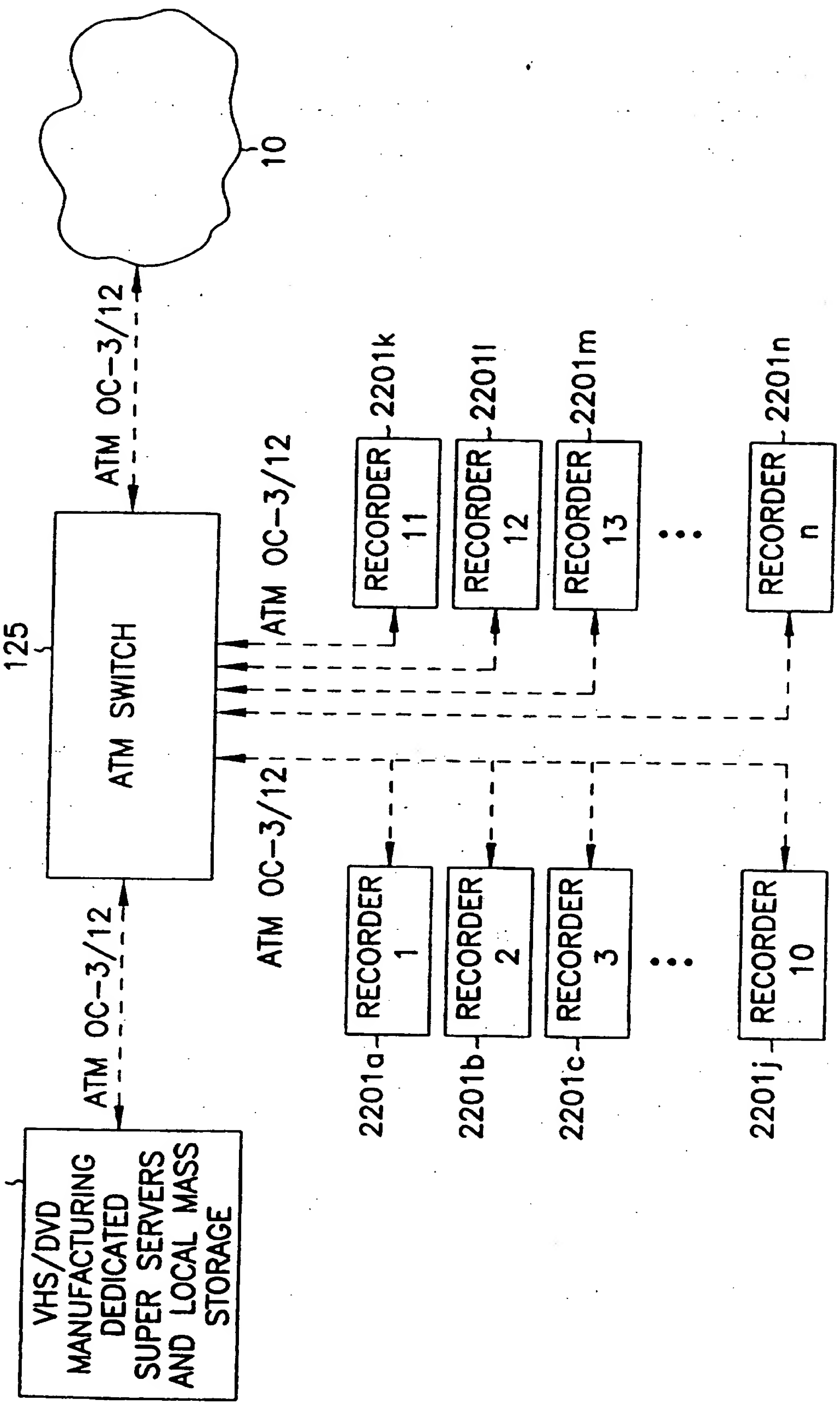
10
ATM OC-3/12
125
ATM SWITCH
ATM OC-3/12
ATM OC-3/12
ATM OC-3/12
RECORDER 11
RECORDER 12
RECORDER 13
RECORDER n
2201k
2201l
2201m
2201n
RECORDER 1
RECORDER 2
RECORDER 3
RECORDER 10
2201a
2201b
2201c
2201j
117
VHS/DVD MANUFACTURING DEDICATED SUPER SERVERS AND LOCAL MASS STORAGE

FIG. 22

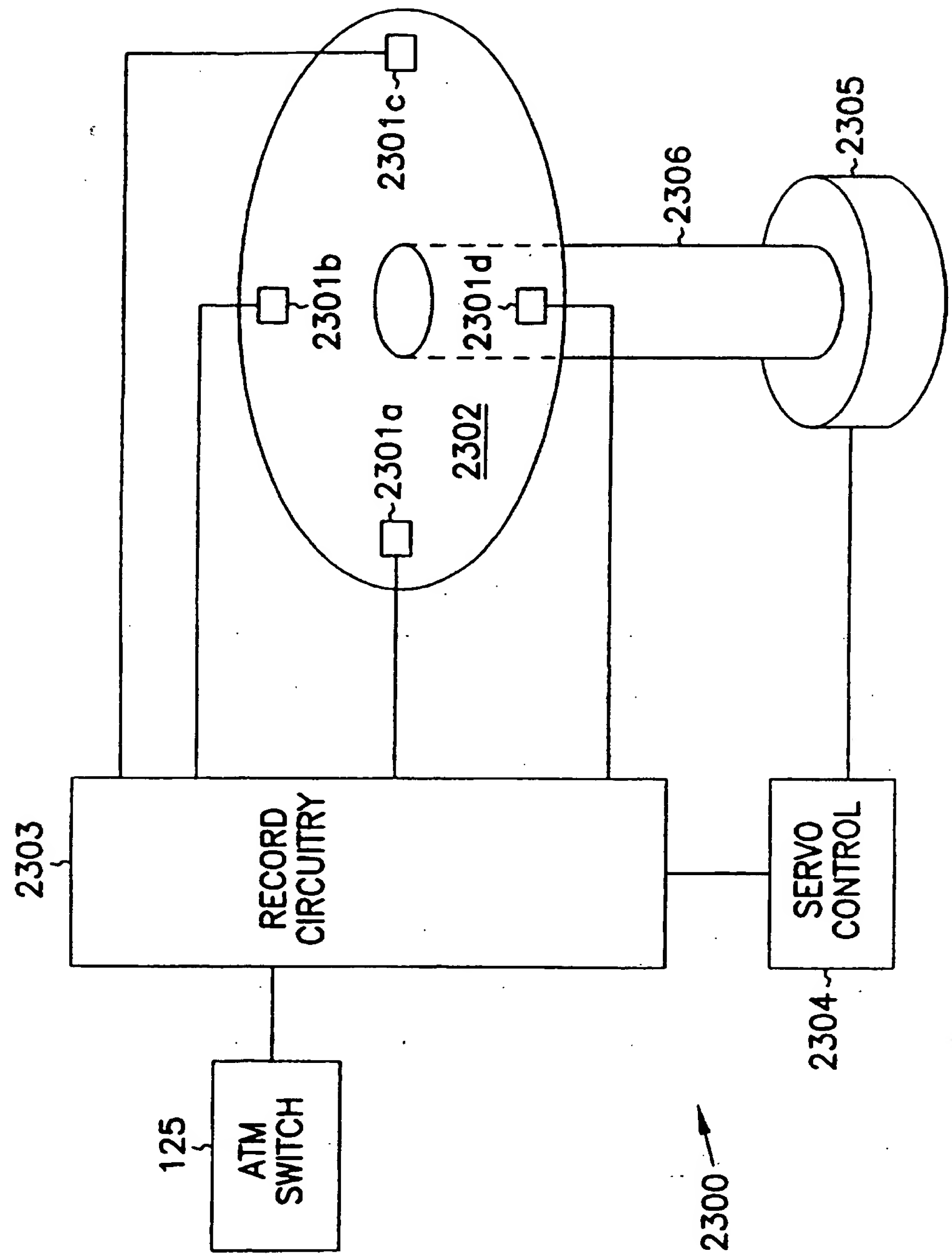
125
ATM SWITCH
2303
RECORD CIRCUITRY
SERVO CONTROL
2304
2300
2301a
2301b
2301c
2301d
2302
2305
2306

FIG. 23

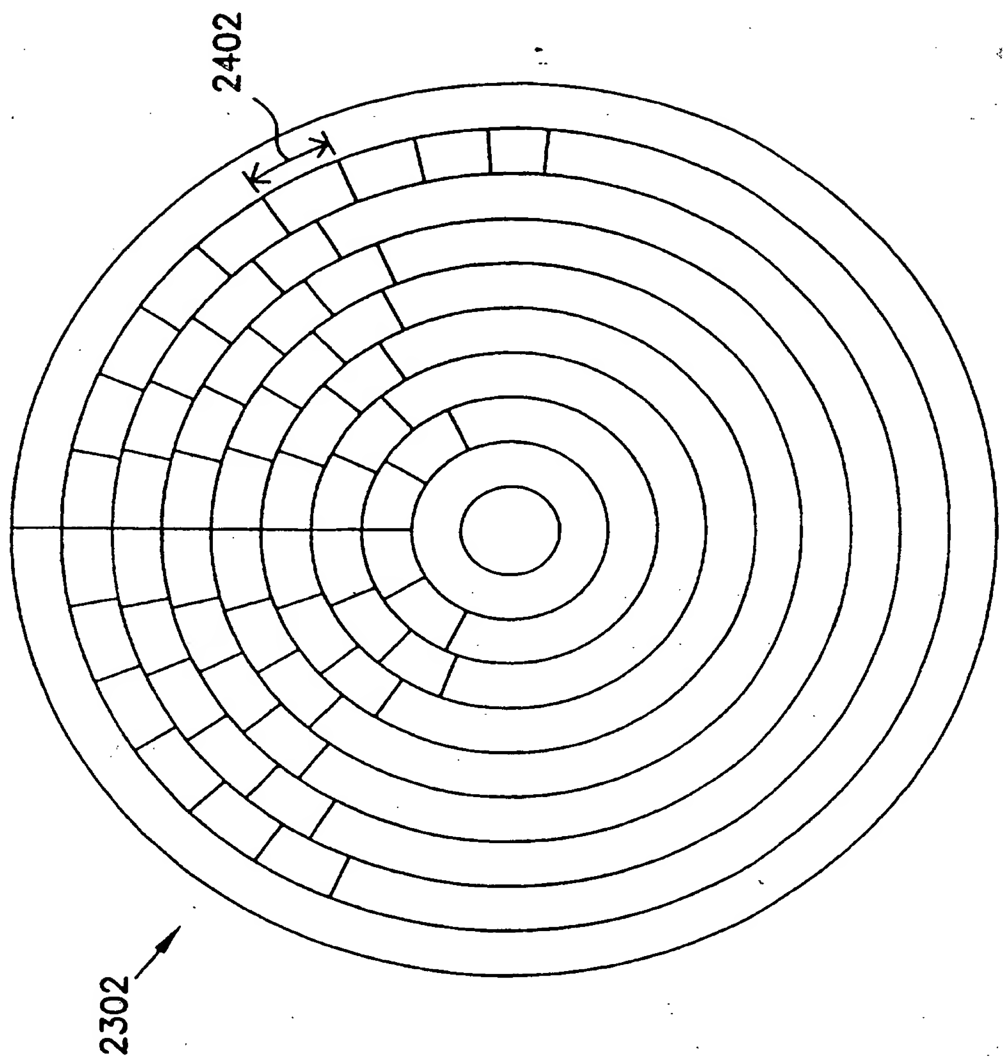

FIG. 24

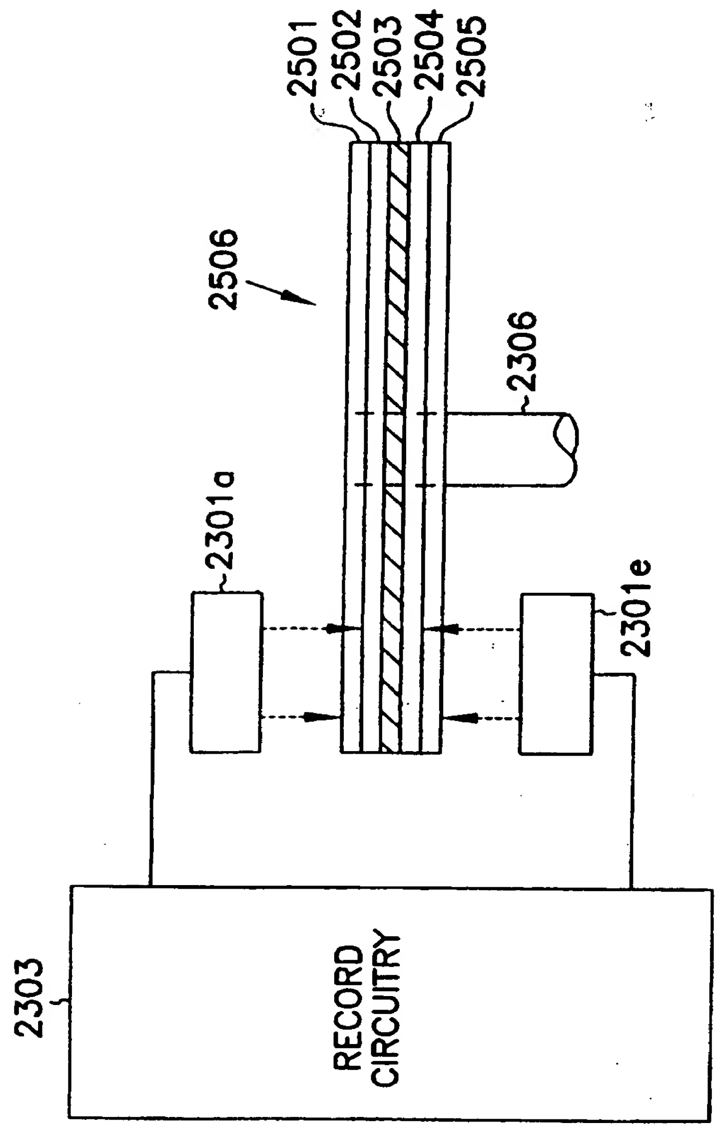
2501
2502
2503
2504
2505
2506
2306
2301a
2301e
2303
RECORD CIRCUITRY

FIG. 25

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/04432

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G11B27/00 G11B27/02 G07F17/16 G11B7/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G11B G07F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 487 296 A (MATSUSHITA ELECTRIC IND CO LTD) 27 May 1992 see the whole document ---	1-3,6,8, 10
A	EP 0 643 388 A (MATSUSHITA ELECTRIC IND CO LTD) 15 March 1995 see the whole document ---	1-3,6,8, 10
A	US 4 845 529 A (PEARSON ROBERT F ET AL) 4 July 1989 see the whole document ---	1,9
A	EP 0 649 121 A (IBM) 19 April 1995 see the whole document ---	13
A	US 5 041 921 A (SCHEFFLER ROBERT G) 20 August 1991 see the whole document -----	13

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Information on patent family members

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